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DEVELOPMENT OF A MANAGEMENT PLAN FOR CRANEY ISLAND DISPOSAL AREA

by

Michael R. Palermo, F. Douglas Shields
and Donald F. Hayes

Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Craney Island disposal area is a 2500-acre confined dredged material disposal site located near Norfolk, Virginia, one of the largest such sites in the Nation. The purpose of constructing such a diked disposal area is twofold: (a) to provide adequate storage capacity for dredged material over the design life of the facility and (b) to provide adequate sedimentation of dredged solids to maintain water quality of effluent.

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20. ABSTRACT (Continued).

Plans for the site were developed in the early 1940's to provide a long-term disposal area for material dredged from channels and ports in the Hampton Roads area. Construction of dikes at Craney Island was completed in 1957, and material has since been placed almost continuously within the disposal area using both direct pipeline discharge and hopper pumpout. Over 130 million cu yd has been placed within the containment to date, and maintenance requirements now average 5 million cu yd per year. The average dredged material fill elevation is now +15 ft mean low water (MLW), and stability analyses indicate that an elevation of +30 ft MLW is feasible.

Adequate dredged material disposal areas within the Hampton Roads vicinity are becoming increasingly difficult to secure. A management plan for the Craney Island disposal area was therefore developed to ensure the most effective use of the containment in future years. Objectives for the plan include the following: (a) maximize volumetric disposal capacity, (b) dewater and densify fine-grained material to the greatest extent feasible, (c) reclaim and remove usable material for productive use, (d) maintain acceptable water quality of effluent, and (e) abide by all legal and policy constraints.

Development of the management plan included an extensive evaluation of management alternatives based on data accumulated through field investigations and laboratory testing. Alternative schemes to subdivide the disposal area using interior dikes were evaluated from the standpoint of both water quality and storage capacity. Management and operational guidelines were then developed to ensure the most efficient utilization of the disposal area and to provide maximum storage capacity within each of the subcontainments. Guidance was also provided concerning construction procedures and modifications required of the existing facility. Technology regarding confined dredged material disposal developed during the Corps of Engineers Dredged Material Research Program (DMRP) was extensively used in the plan development.

Implementation of the management plan will realize a significant savings in available storage capacity without reducing effluent water quality. It is estimated that projected disposal operations could continue for approximately 36 years (until an average fill elevation of +30 ft is attained) using the recommended management approach, as compared to an estimated 19 years using the present mode of operation.

PREFACE

The work described in this report was a joint effort of the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, and the U. S. Army Engineer District, Norfolk (ND). The report documents the development of a comprehensive plan for management and operation of the Craney Island disposal area, Norfolk, Virginia.

Through the initiative of COL Douglas L. Haller, CE, District Engineer, ND, initial development of the scope and concept for the management plan was accomplished through the Dredging Operations Technical Support (DOTS) Program, managed by the Environmental Laboratory (EL), WES, Mr. Charles C. Calhoun, Program Manager.

The plan development was conducted during the period January to September 1980 by Mr. Michael R. Palermo, Mr. F. Douglas Shields, and Mr. Donald F. Hayes, all of the Water Resources Engineering Group (WREG), Environmental Engineering Division (EED), EL, WES. Acknowledgement is made to members of the Norfolk District Craney Island Management Plan Committee (CIMPC), who developed specific goals for the management plan and furnished significant input into the plan development: Mr. William E. Crouthers, Chief, Construction/Operations Division (Chairman, CIMPC); Mr. Lloyd Rice, Chief, Real Estate Division; Mr. Tom Lawless, Chief, Operations and Maintenance Branch; Mr. Ronn Vann, Chief, Dredging Management Branch; Mr. Frank Wooten, Chief, Water Resources Planning Branch; Mr. Gene Whithurst, Chief, Waterways and Harbors Section; and Mr. Carl Anderson, Chief, Geotechnical Engineering Section.

Significant contributions were also made by Mr. Rivers Wescott, Operations and Maintenance Branch; Mr. David Pezza and Mr. Ron Buck, Geotechnical Engineering Section; Mr. P. E. Gundel, Civil Engineering Section; and Mr. Jim Melchor, Water Resources Planning Branch.

Dr. T. A. Haliburton and Ms. Cecilia Hayes of Haliburton and Associates, Stillwater, Oklahoma, and Mr. Fenton Durand of Lone Star Industries, Inc., Southeast Region, Norfolk, Virginia, also contributed to the plan development through contracted efforts. Special thanks is given to Mr. Crouthers for his support and contributions for the plan development.

The report was written by Messrs. Palermo, Shields, and Hayes, under the direct supervision of Dr. R. L. Montgomery, Chief, WREG, and under the general supervision of Mr. A. J. Green, Chief, EED, and Dr. John Harrison, Chief, EL.

District Engineer of ND during the development of the plan was COL Douglas L. Haller, CE, and Commander and Director of WES was COL Nelson P. Conover, CE. Technical Director of WES was Mr. F. R. Brown.

This report should be cited as follows:

> Palermo, M. R., Shields, F. D., and Hayes, D. F. 1981. "Development of a Management Plan for Craney Island Disposal Area," Technical Report EL-81-11, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	0.4046873	hectares
cubic feet per hour	0.02831685	cubic metres per hour
cubic feet per second	0.02831685	cubic metres per second
cubic feet per second per foot	0.0929	cubic metres per second per metre
cubic yards	0.7645549	cubic metres
feet	0.3048	metres
feet per hour	0.0000847	metres per second
feet per second	0.3048	metres per second
gallons (U. S. liquid)	0.003785412	cubic metres
horsepower (electric)	746.00	watts
inches	0.0254	metres
miles (U. S. statute)	1609.347	metres
pints (U. S. liquid)	0.0004731765	cubic metres
pounds (force) per square inch	6894.757	pascals
pounds (mass)	0.4535924	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
pounds (mass) per square foot	4.882428	kilograms per square metre
pounds (mass) per hour per square foot	0.0013552	kilograms per second per square metre
square feet	0.09290304	square metres
square inches per day	0.00064516	square metres per day
square inches per pound (mass)	0.00142	square metres per kilogram
tons (short) per square foot	9765,1743	kilograms per square metre

DEVELOPMENT OF A MANAGEMENT PLAN FOR

CRANEY ISLAND DISPOSAL AREA

PART I: MANAGEMENT PLAN

Introduction

Background

1. The Craney Island disposal area is a 2500-acre* confined dredged material disposal site located near Norfolk, Viginia (Figures 1 and 2). Plans for the site were developed in the early 1940's to

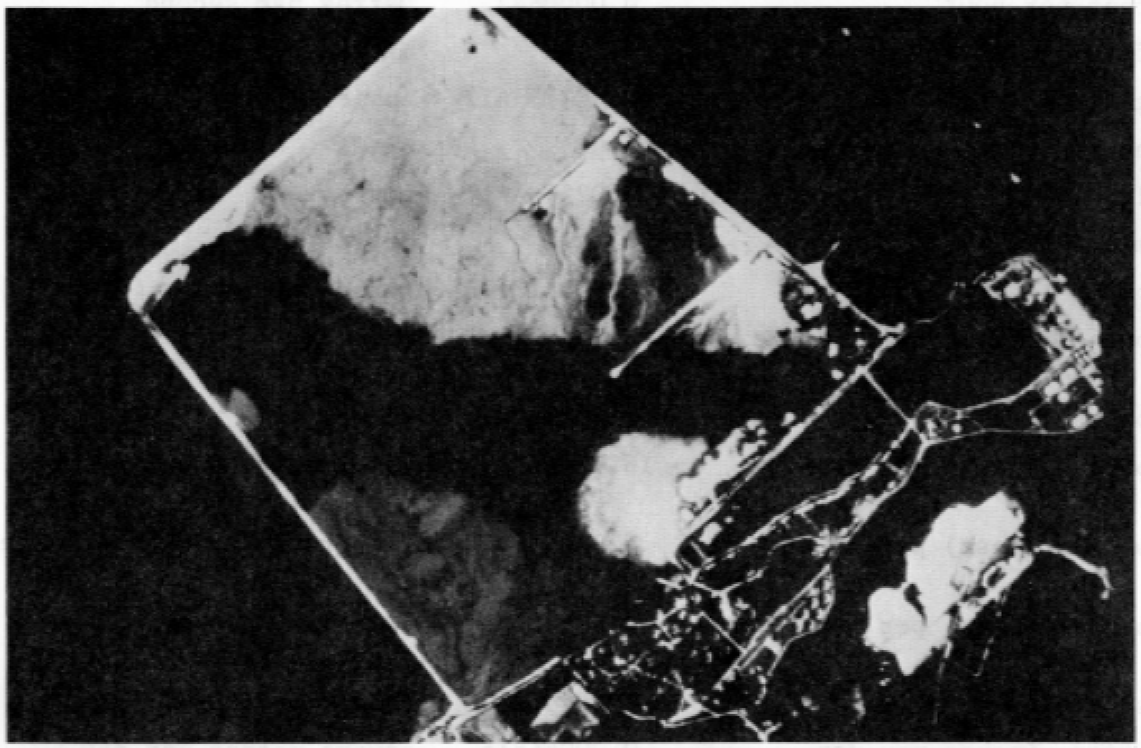

Figure 1. Infrared aerial photo of Craney Island dredged material containment facility, Norfolk, Virginia

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 9.

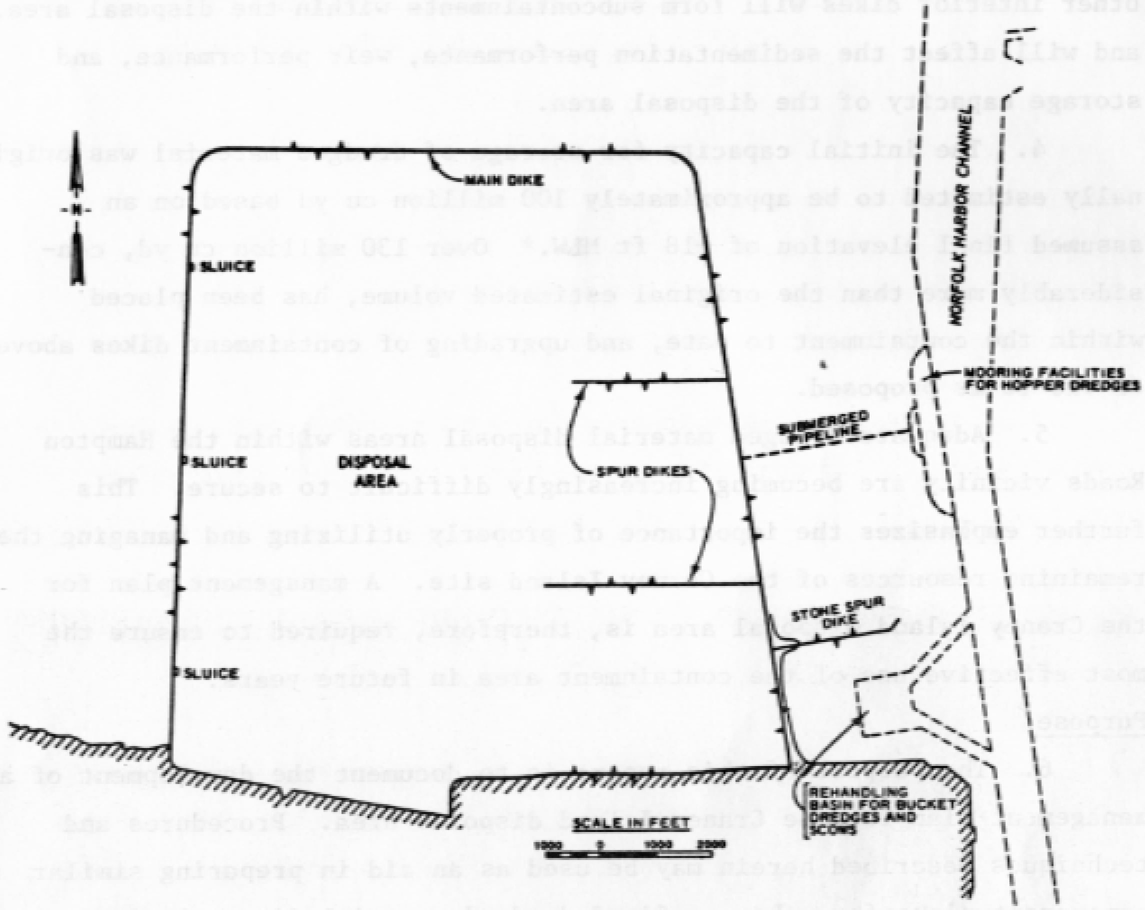

Figure 2. Layout of Craney Island disposal area

provide a long-term disposal area for material dredged from channels and ports in the Hampton Roads area (Norfolk District 1953). The purpose of constructing such a diked disposal area is twofold: (a) to provide adequate storage capacity for dredged material over the design life of the facility and (b) to provide adequate sedimentation of dredged solids to maintain water quality of effluent.

2. Construction of dikes at Craney Island was initiated in August 1954 and completed in January 1957. Material has been placed almost continuously within the disposal area using both direct pipeline discharge and hopper pumpout.

3. Construction of two interior dikes across the containment has been initiated using debris and end-dumped sand. Closure of these or

other interior dikes will form subcontainments within the disposal area, and will affect the sedimentation performance, weir performance, and storage capacity of the disposal area.

4. The initial capacity for storage of dredged material was originally estimated to be approximately 100 million cu yd based on an assumed final elevation of +18 ft MLW.* Over 130 million cu yd, considerably more than the original estimated volume, has been placed within the containment to date, and upgrading of containment dikes above el +18 ft is proposed.

5. Adequate dredged material disposal areas within the Hampton Roads vicinity are becoming increasingly difficult to secure. This further emphasizes the importance of properly utilizing and managing the remaining resources of the Craney Island site. A management plan for the Craney Island disposal area is, therefore, required to ensure the most effective use of the containment area in future years.

Purpose

6. The purpose of this report is to document the development of a management plan for the Craney Island disposal area. Procedures and techniques described herein may be used as an aid in preparing similar management plans for other confined dredged material disposal sites.

Objectives and scope

7. The management plan includes operation and management guidelines to achieve the following specific objectives:

- a. Maximize volumetric disposal capacity over the remaining service life of the containment.
- b. Dewater and densify fine-grained material, to the greatest extent feasible, to further increase storage capacity and improve potential for productive use.
- c. Reclaim and remove usable coarse-grained and dewatered fine-grained material for productive use both on and off site.
- d. Maintain acceptable water quality of effluent.

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* All elevations (el) cited herein are referred to Corps of Engineers Mean Low Water Datum which is 1.50 ft below mean sea level (msl).

e. Abide by legal and policy constraints associated with all proposed actions or options.

8. The development of the management plan includes designs to maintain acceptable water quality of effluent for subcontainments resulting from various interior dike alignments. Management and operational guidelines are developed to ensure the most efficient utilization of the disposal area and to provide maximum storage capacity within each of the subcontainments. Guidance is also provided concerning construction procedures and modifications required of the existing facility.

9. The report includes descriptions of all information and data accumulated, assumptions required, alternatives considered, methodologies and procedures used, and the overall rationale governing the final recommendations for operation and management of the Craney Island disposal area. Recommendations are made concerning implementation of the guidelines, monitoring of the progress and effectiveness of the management activities, and any future revision or updating of the guidelines.

10. Concise and functional guidelines are provided for operation of the Craney Island disposal area for various dredging activities, and for management both during and between dredging activities. Guidance is provided for preparation of subcontainments prior to dredging, management of ponded water, operation of inlets and weir structures, monitoring of activities, sequencing and placement of materials, management of surface water after dredging is completed, measures for dewatering fine-grained material, requirements for use of material in dike upgrading, and requirements for reclamation and use of materials offsite.

Authority

11. The authority for development and implementation of disposal area management plans is recognized in Section 148 of PL 94-587:

> Sec. 148. The Secretary of the Army, acting through the Chief of Engineers, shall utilize and encourage the utilization of such management practices as he determines appropriate to extend the capacity and useful life of dredged material disposal areas such that the need for new dredged material disposal areas is kept to a minimum. Management practices authorized by this section shall include, but not be

limited to, the construction of dikes, consolidation and dewatering of dredged material, and construction of drainage and outflow facilities.

Related studies

12. Previous studies under the Corps of Engineers Dredged Material Research Program (DMRP) have resulted in general guidelines for designing, operating, and managing dredged material containment areas, dewatering confined dredged material, and disposal area reuse management. This guidance is reported in U. S. Army Engineer Waterways Experiment Station (WES) Technical Reports DS-78-10, DS-78-11, and DS-78-12 (Palermo, Montgomery, and Poindexter 1978; Haliburton 1978; and Montgomery et al. 1978). Development of specific guidance in this report for managing future disposal activities in the Craney Island disposal area is based on the general guidance provided by the DMRP. Only implementable procedures were considered in developing overall guidance for operation and management of the Craney Island disposal area. New techniques or concepts, even if recommended or thought to be technically feasible by recent DMRP research, were not considered in developing guidance if such techniques were not economically feasible and readily implementable.

13. Several studies concerning the initial design, planned use, and upgrading of the Craney Island disposal area have been previously performed (Norfolk District 1953, 1974). Background information and data contained in these studies are summarized herein as needed for completeness. In addition, complete records of material sources, dredging quantity, and data concerning disposal operations have been maintained for the Craney Island project since its inception. These records proved invaluable in developing the management plan.

Report organization

14. The management plan is contained in its entirety in this part. Supporting information regarding sampling, testing, and analysis of data is contained in Parts II through X and the Appendices.

Recommended Management Approach

15. The recommended approach regarding operation, management, and

construction requirements for the Craney Island disposal area is as follows:

a. The disposal area should be subdivided, forming three subcontainments, by completing the existing interior dikes.

b. Main retaining dikes should be constructed along alignments at a bench distance of approximately 1000 ft to allow eventual placement of dredged material to el +30 ft. New weirs will also be required.

c. Once closure of interior dikes is completed, disposal should be alternated annually between subcontainments, allowing for a 1-year active disposal cycle followed by a 2-year inactive cycle for each respective subcontainment.

d. Operation of the active subcontainment will require a ponding depth of 2 to 3 ft, depending on inflow rate. Inflow points should be limited to the east side of the subcontainment.

e. Management of inactive subcontainments should emphasize removal of surface water, prevention of ponding, and construction of surface drainage systems to efficiently remove precipitation and dewater the fine-grained dredged material. Surface drainage should be accomplished by constructing periphery trenches adjacent to the subcontainment dikes using draglines and interior trenches using amphibious rotary trenchers or other suitable equipment.

f. Dikes should be continuously upgraded as conditions allow, primarily using material excavated from periphery trenches and accumulated coarse-grained material as required.

g. A comprehensive sampling, testing, and monitoring program should be developed to verify benefits attained and to form a basis for changes in mode of operation and management.

16. The above management approach is discussed in detail in the following paragraphs.

Expected Benefits

17. Implementation of the management plan described herein will realize a significant savings in available storage capacity without

reducing effluent water quality. It is estimated that projected disposal operations could continue for approximately 36 years (until an average fill elevation of +30 ft is attained) using the recommended management approach, as compared to an estimated 19 years using the present mode of operation. Completion of interior dikes and proper management of surface water will also dewater dredged material for use in constructing and upgrading dikes.

Construction

18. This section describes in general terms the sequencing of construction activities necessary to complete interior dikes and upgrade the main retaining dikes along benched alignments. Foundation analysis (Norfolk District 1971) has indicated that construction of main retaining dikes to elevation of +30 ft is possible using a bench distance of approximately 1000 ft. The ideal dike section is shown in Figure 3. Dike construction at Craney Island has been successfully accomplished over a long time period, gradually raising dike sections as material becomes available. This approach should be continued to achieve the higher grades required to eventually contain the dredged material to el +30 ft.

19. Sequencing of construction for various reaches as described in this section refers to the initial placement of the dike section along the new alignment. It is recognized that once an alignment is initially completed, upgrading of the entire system to an eventual average grade of +30 ft will occur over a period of years, at a pace consistent with the rate of filling and availability of material.

Stages of construction

20. The sequence of construction is best described in stages, each stage corresponding to approximately a 1-year interval. It is assumed that implementation of construction activities under the management plan can be initiated (Stage 1) under existing authorizations and funding sources. Additional sources of funding may be later required for larger construction contract items. It is further assumed that Stage 1

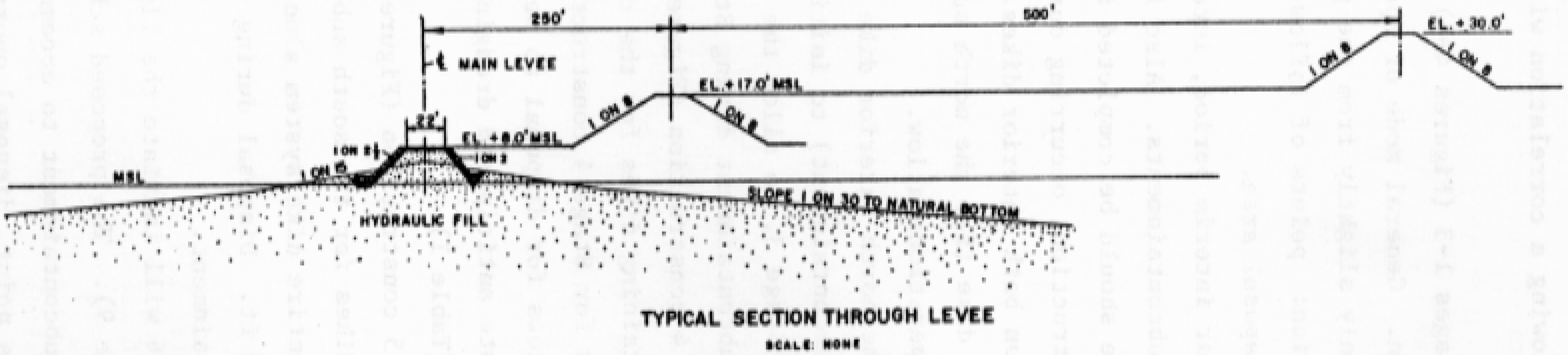


Figure 3. Ideal cross section of retaining dike, grade +30 ft

construction will be initiated in FY 81, setting the time frame for proposed construction and allowing a correlation with anticipated dredging schedules.

21. Stages 1-3. Stages 1-3 (Figures 4-6) correspond to a 3-year period of interim operation. General mode of operation during the interim period will differ only slightly from the present mode of operation with one major exception: points of inflow will be constrained to the eastern side of the disposal area.

22. During the 3-year interim period, interior dikes should be completed, forming three subcontainments. Also initial dike sections for the main retaining dike should be completed for the north subcontainment. Stages 1 and 2 construction, occurring during FY 81 and FY 82, should emphasize progress on both interior dikes. Also, preliminary work on the main retaining dike (for the north subcontainment) could be accomplished as disposal operations allow.

23. Completion of the north interior dike section and main retaining dikes (for the north subcontainment) to initial elevation must be accomplished by the end of Stage 3, to allow the disposal operations to be confined to the north subcontainment during Stage 4.

24. Stage 4. Stage 4 construction (Figure 7) will emphasize completion of benched main retaining dikes for the center subcontainment. The proposed schedule calls for Stage 4 construction to occur during FY 84. This time frame allows for disposal to be confined to the north subcontainment to accommodate anticipated dredging at Sewells Point and Newport News during FY 84 (Table 1).

25. Stage 5. Stage 5 construction (Figure 8) will emphasize completion of main retaining dikes for the south subcontainment, marking initial completion of the entire dike system along alignments required for eventual filling to +30 ft. Disposal during this stage will be confined to the center subcontainment.

26. Stage 6. Stage 6 will initiate the first disposal in the south subcontainment (Figure 9). The proposed schedule (Table 1) allows for disposal in the south subcontainment to accommodate dredging of the Rehandling Basin. From this point, disposal operations will alternate

Figure 4. Stage 1 construction plan

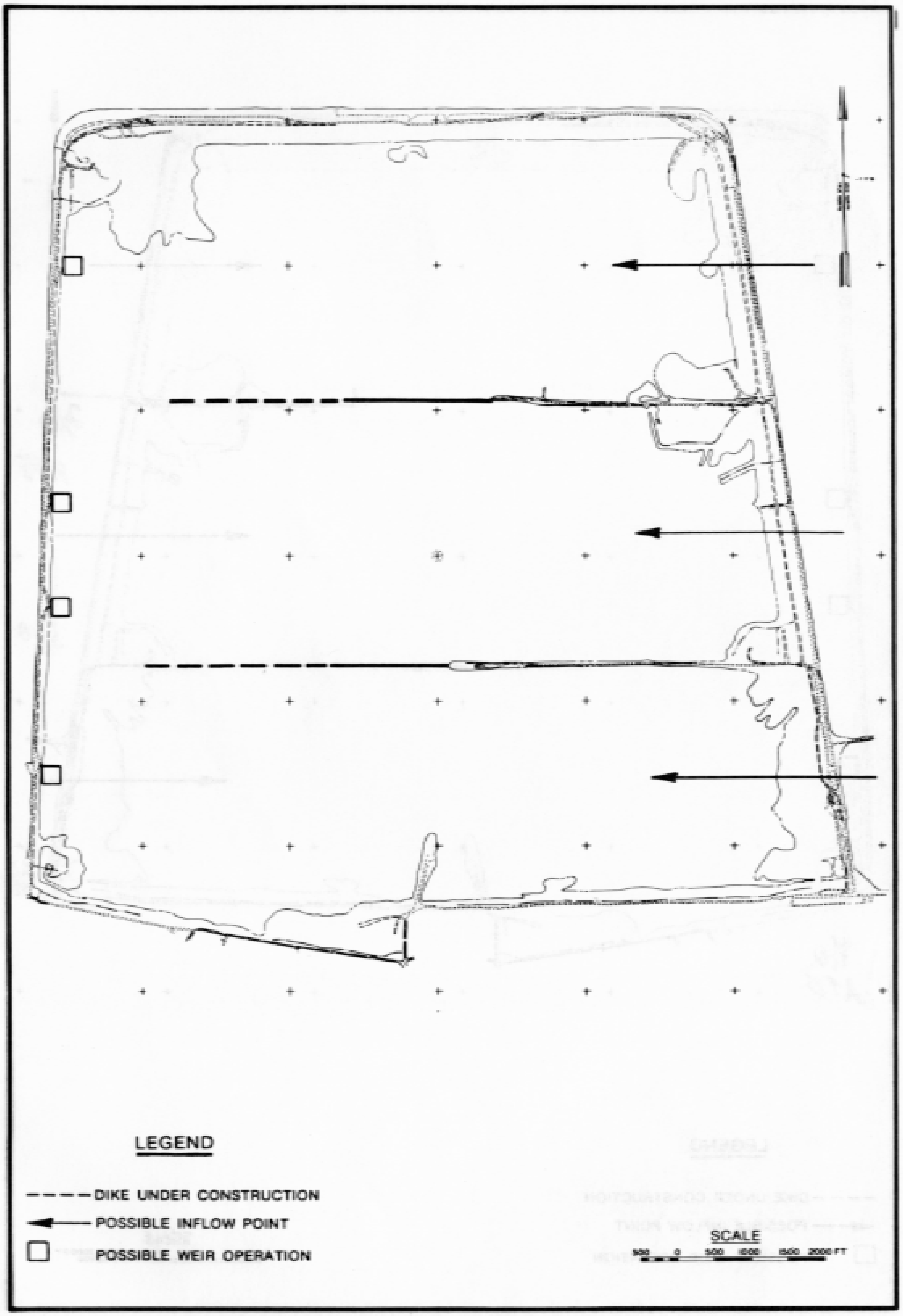


Figure 5. Stage 2 construction plan

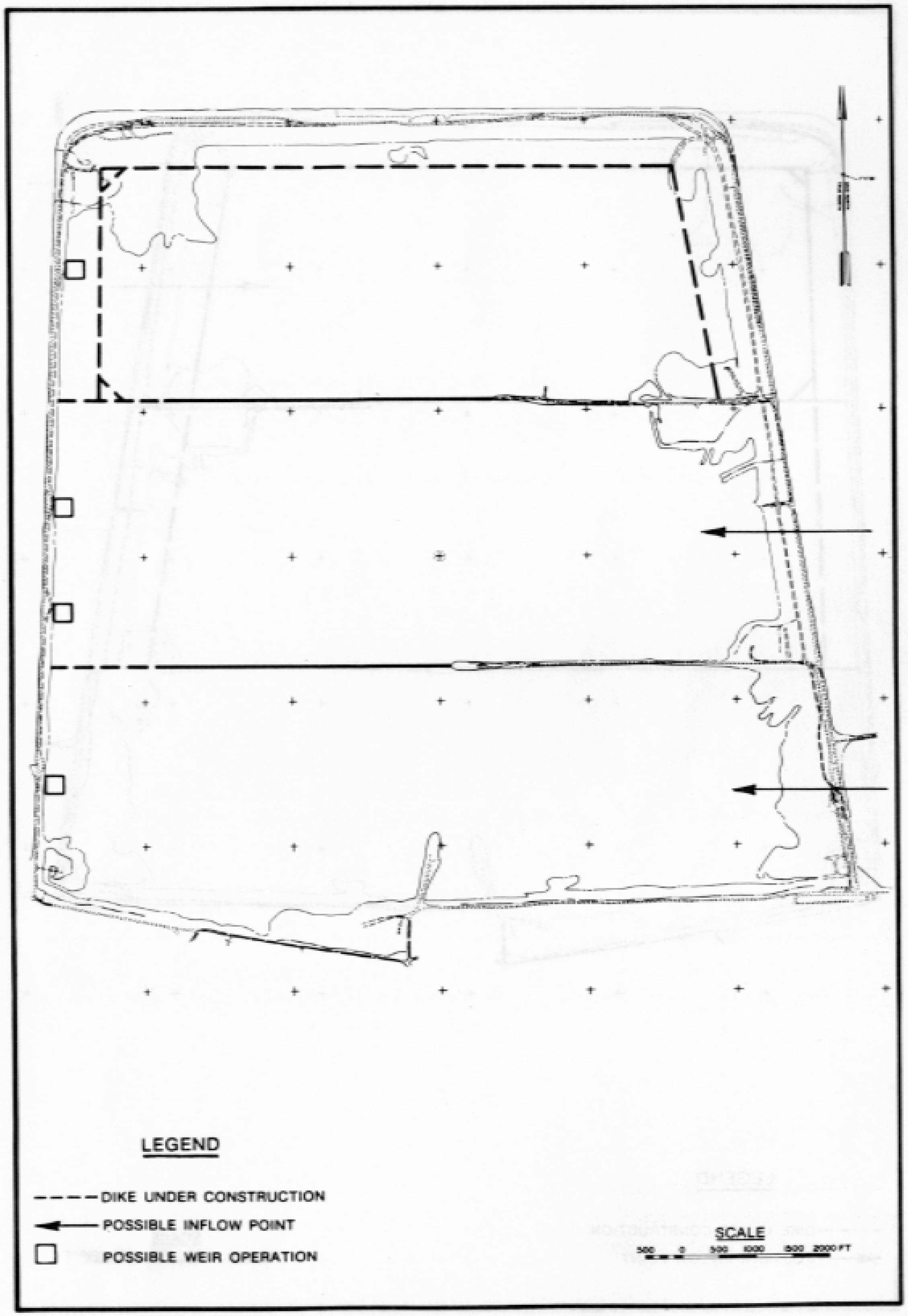


Figure 6. Stage 3 construction plan

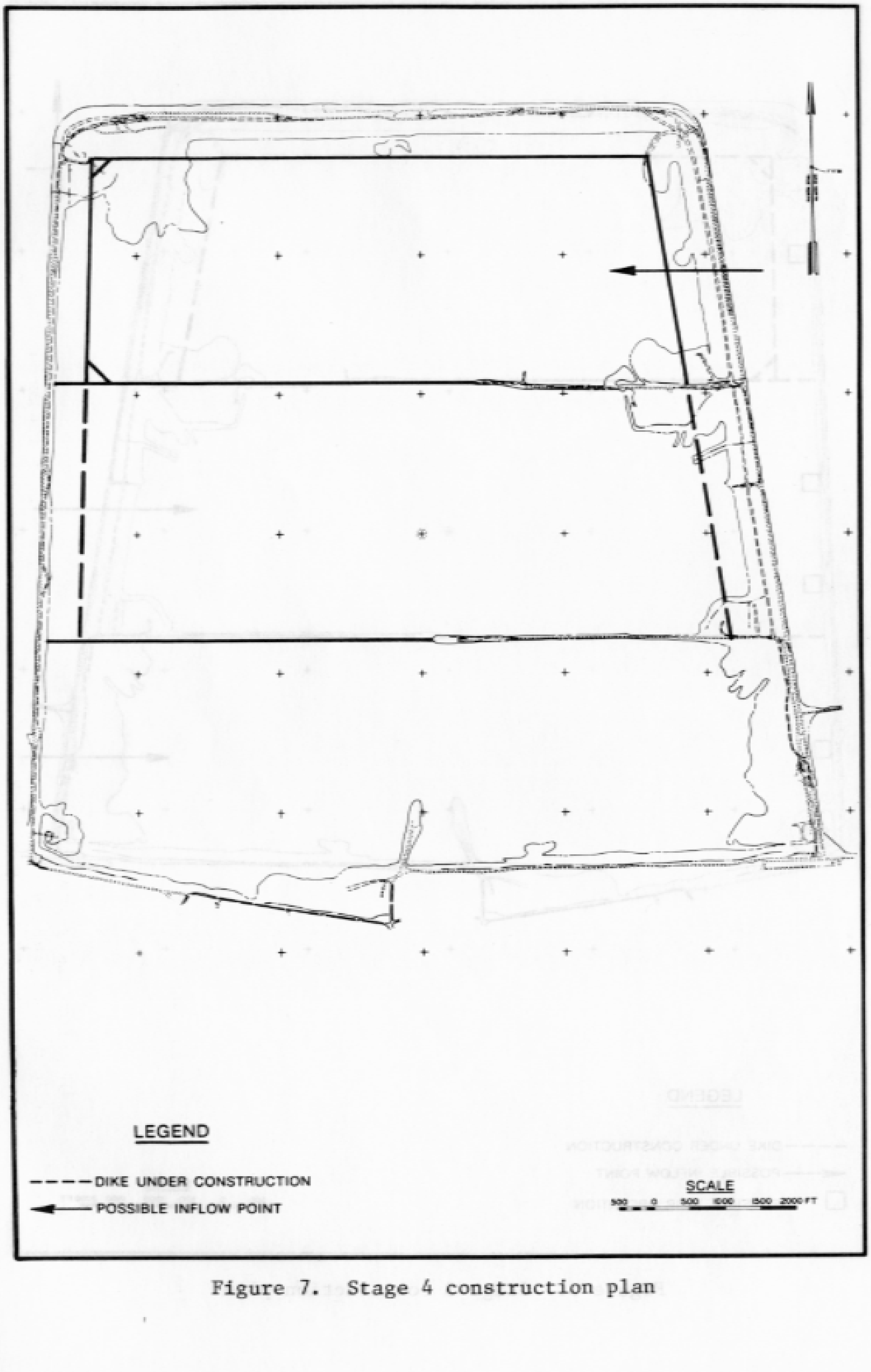


Figure 7. Stage 4 construction plan

Table 1

Revised Estimate of Material to be Placed in Craney Island Disposal Area, 1979-1992

Source	Year/Point of Inflow* - Quantity, 10^3 cu yd													
	1979 A	1980 A	1981 A	1982 A	1983 A	1984 B	1985 E	1986 C	1987 B	1988 E	1989 C	1990 B	1991 E	1992 C
Norfolk Harbor	500	800	500	1800	1500	800	1200	800	2300	1500	800	1500	800	1800
Sewells Pt.	1600					2000					1600			
Newport News		1400				(700)		1400 (0)	(700)			(700)		1400 (0)
Rehandling Basin		1300			1300			1300			1300			1300
Southern Branch			400				600				400			
Misc. Contracts	200	200	500	500	1000	500	1000	500	500	1000	500	1000	500	500
Navy Dept. Dredg.	700	700	700	700	700	700	1000	700	1000	700	700	700	1000	700
Private Permit Dredge	800	800	2500	2500	800	1000	800	800	1200	800	800	800	1000	800
TOTAL	3800	5200	4600	5500	5300	5000 (5700)	4600	5500 (4100)	5000 (5700)	4000	6100	4000 (4700)	3300	6500 (5100)

Note: Quantities in parentheses indicate proposed revisions.

* Notation of points of inflow is as follows: A = as required by Table 4; B, E, C = north, central, and south subcontainments, respectively. See Figure 27.

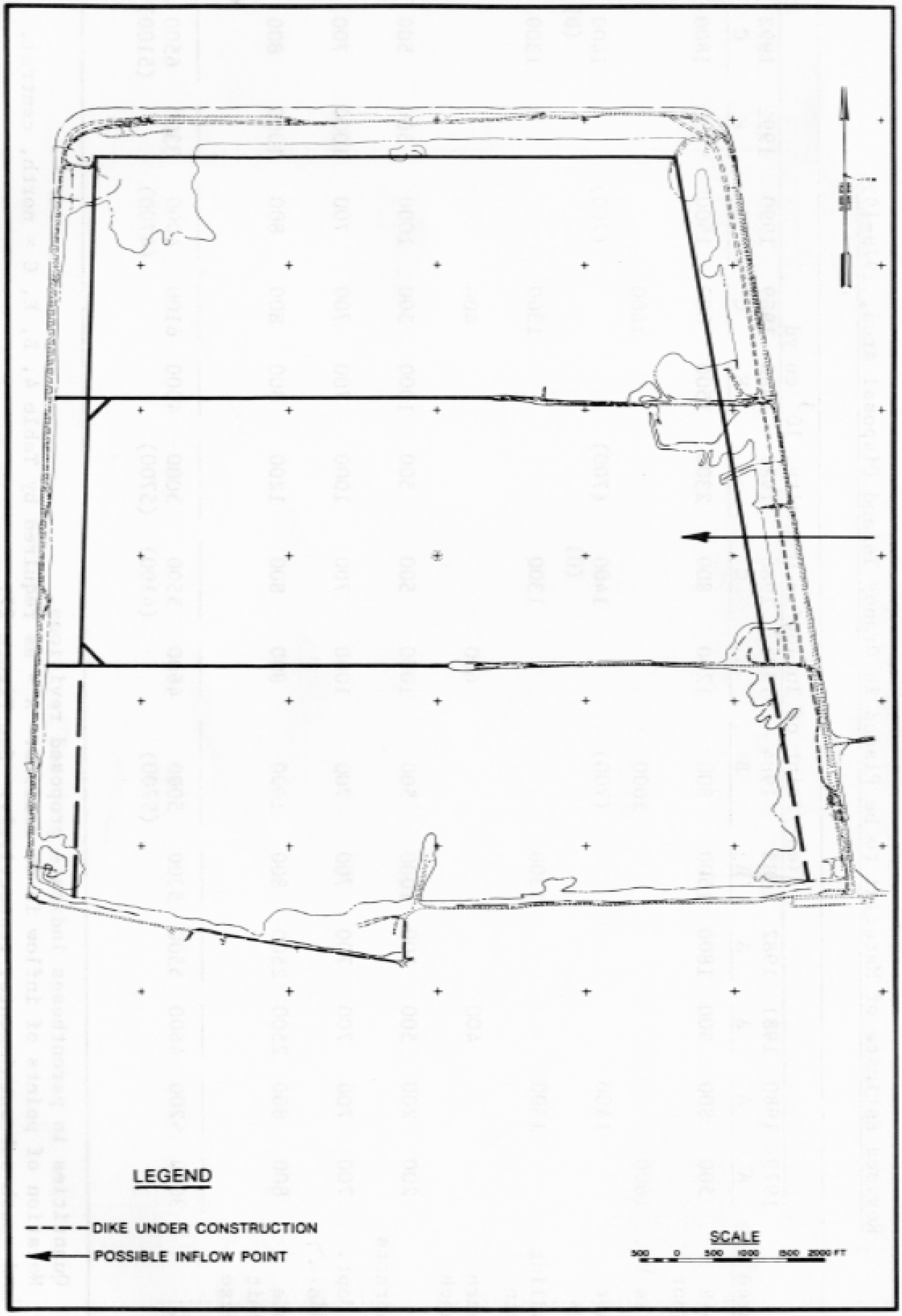


Figure 8. Stage 5 construction plan

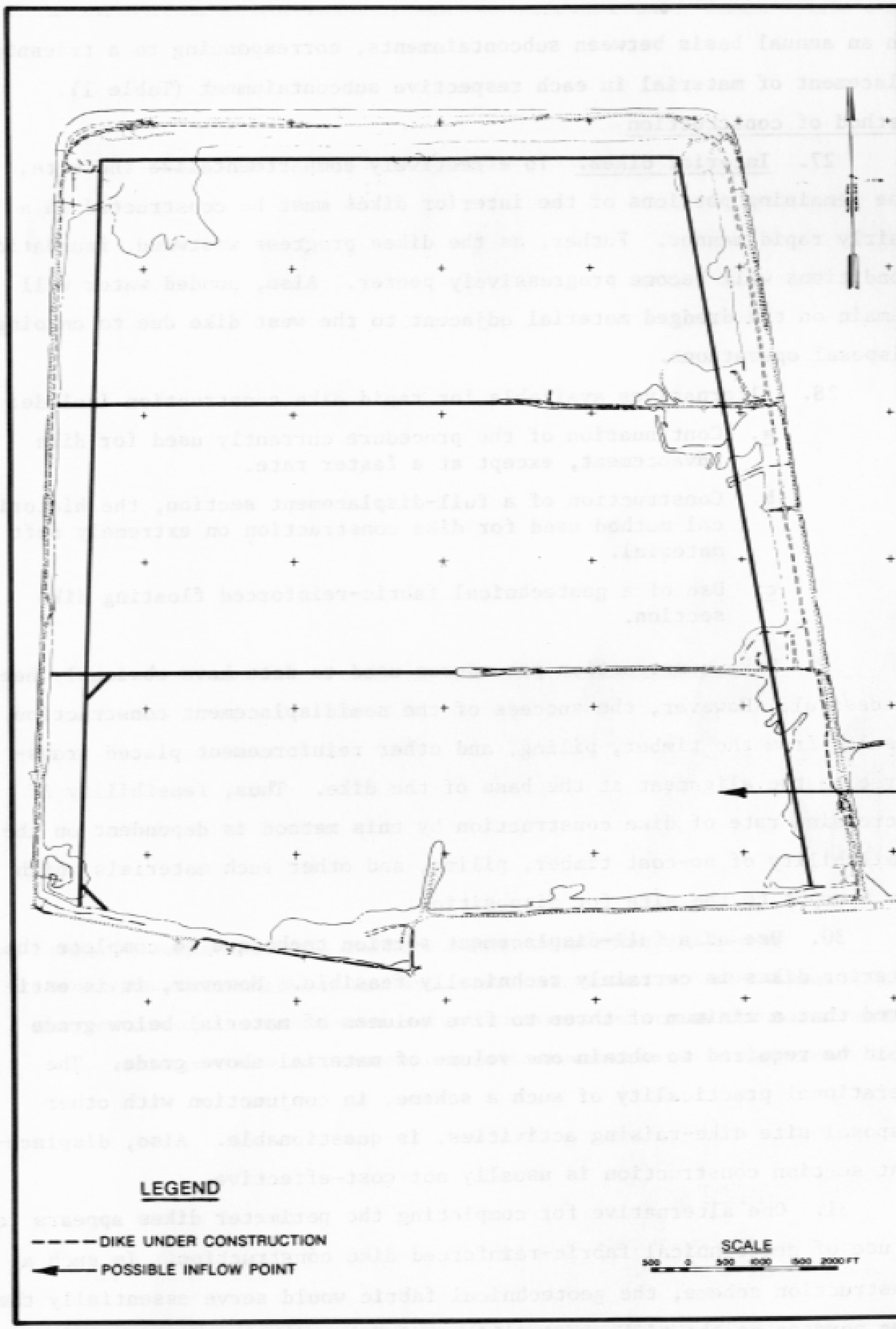


Figure 9. Stage 6 construction plan

on an annual basis between subcontainments, corresponding to a triennial placement of material in each respective subcontainment (Table 1).

Method of construction

27. Interior dikes. To effectively compartmentalize the site, the remaining portions of the interior dikes must be constructed in a fairly rapid manner. Futher, as the dikes progress westward, foundation conditions will become progressively poorer. Also, ponded water will remain on the dredged material adjacent to the west dike due to ongoing disposal operations.

28. Alternatives available for rapid dike construction include:

a. Continuation of the procedure currently used for dike advancement, except at a faster rate.

b. Construction of a full-displacement section, the historical method used for dike construction on extremely soft material.

c. Use of a geotechnical fabric-reinforced floating dike section.

29. Dike construction procedures used to date have obviously been successful. However, the success of the semidisplacement construction results from the timber, piling, and other reinforcement placed transverse to the alignment at the base of the dike. Thus, feasibility of increasing rate of dike construction by this method is dependent on the availability of no-cost timber, piling, and other such materials which are brought to the site for disposition.

30. Use of a full-displacement section technique to complete the interior dikes is certainly technically feasible. However, it is estimated that a minimum of three to five volumes of material below grade would be required to obtain one volume of material above grade. The operational practicality of such a scheme, in conjunction with other disposal site dike-raising activities, is questionable. Also, displacement section construction is usually not cost-effective.

31. One alternative for completing the perimeter dikes appears to be use of geotechnical fabric-reinforced dike construction. In such a construction scheme, the geotechnical fabric would serve essentially the same purpose as the timber and piling reinforcement currently used.

Proper placement of fabric would allow construction of a "floating" section with essentially minimal bearing displacement, eliminating possible horizontal splitting or foundation bearing/embankment rotational failures. The final decision regarding the use of fabric-reinforced construction technique should be based on field trial.

32. Main retaining dikes. A stepped or benched dike construction technique using material adjacent to the dike alignment is recommended for upgrading the main retaining dikes, supplemented as required by truck-hauled coarse-grained material and use of fabric-reinforced sections in extremely wet areas. The recommended operational procedures call for locating all inflow points along the eastern dike. The natural slope of the fine-grained material is approximately 5 ft in 10,000 ft, requiring the overall dike construction to be tailored to contain this slope. The east and west dikes would therefore be constructed to approximate crown elevations of +32.5 and +27.5 ft, respectively, while the north and south dikes would require a sloping crown elevation from east to west.

33. East dike. The majority of all accumulated coarse-grained material is now located along the east dike, providing a convenient source for construction material. Few problems have been encountered in progressively raising this dike due to the firm foundation afforded by the coarse-grained material. The section is now benched approximately 250 ft. In order to reach a required bench distance of 1000 ft, the new alignment will be partially located on the fine-grained dredged material. However, the higher elevation along the eastern portion of the site allows considerable periods of drying. The incremental construction method used successfully for the intermediate north dike section should prove satisfactory for the full 1000-ft bench section along the east dike. Draglines operating on mats pulling up adjacent material should be satisfactory. Additional coarse-grained material can be truck-hauled to points at a greater distance from areas of accumulated coarse material.

34. North dike. At the present time, an extensive area of

accumulated coarse-grained material exists in the NE and NW corners of the disposal area. Construction of a 1000-ft bench section within these corner areas could easily be accomplished by dragline. However, the remainder of the north dike section must be constructed on fine-grained material. This section can be constructed using methods previously used in constructing the intermediate bench section.

35. West dike. The continuously wet condition of the western portion of the disposal area has prevented benching of this dike. However, completion of interior dikes as described previously will allow drying and crust formation during inactive cycles. Flotation draglines and/or conventional draglines operating on mats could then be used to pull up adjacent material to form a base section. In areas where drying has not progressed sufficiently, the fabric-reinforced construction technique could be used. Design of the west dike should be such that a minimum 2-ft pond can be maintained for normal operating conditions throughout the active cycle and a 3-ft pond would be accommodated for shorter periods of high inflow.

36. Weirs. In conjunction with completion of the west dike, a total of six new weir structures, each with effective weir length of 75 ft, is recommended. The structures should be located in the west corners of each subcontainment.

Interim operation

37. Stability considerations for the overall retaining dike dictate that the existing 250-ft bench will allow an average elevation of +17.0 ft within the disposal area interior. The present mode of operation should continue for approximately 3 years to achieve this average elevation. This would take maximum advantage of the present dike alignment and correspondingly greater surface area available for disposal. During this period, efforts to complete the interior dikes (Stages 1-3) must be expedited to ensure their timely completion. Since completion of interior dikes will not have allowed drying on the western side, maintenance of the retaining dike and ponding conditions will be unchanged. However, as the working face of the interior dikes nears the west dike, location of inflow pipe and operation of a weir structure on

opposite sides of the advancing interior dike should be avoided due to potential scour problems.

Operation and Management

38. Guidelines are required for operation and management of the disposal area following completion of interior dikes and main retaining dikes along benched alignments. The guidelines may be categorized as pertaining to general concept of operation, preparation of subcontainments, operation during active cycles, management during inactive cycles, dewatering activities, and monitoring.

General concept of operation and management

39. Guideline 1: Sequence disposal operations between subcontainments on an annual basis. Upon completion of interior dikes, the disposal area will be operated by sequencing disposal between the three subcontainments on an annual basis. Each subcontainment will be operated and managed according to a 1-year active cycle (ongoing disposal operations), followed by a 2-year inactive cycle (management to promote drying). At any given time, one subcontainment will be operated to accommodate disposal operations (active cycle) while the remaining two subcontainments will be managed to promote drying (inactive cycle). This concept is illustrated in Figure 10.

40. The proposed long-term schedule of sequencing is outlined in Table 1. The schedule reflects a slight adjustment from existing projections in order to keep pumping distances to a minimum while disposing only at the eastern side of the disposal area. The lift thickness of dredged material applied during active cycles will vary between approximately 3 and 5 ft, based on projections shown in Table 1. Lift thickness in excess of 6 ft should be avoided to promote optimum drying benefits. If dredging requirements should dictate lifts in excess of 6 ft, disposal for selected contract items should be diverted to other subcontainments (refer to paragraph 197).

41. Guideline 2: Pond water only during active cycles. During

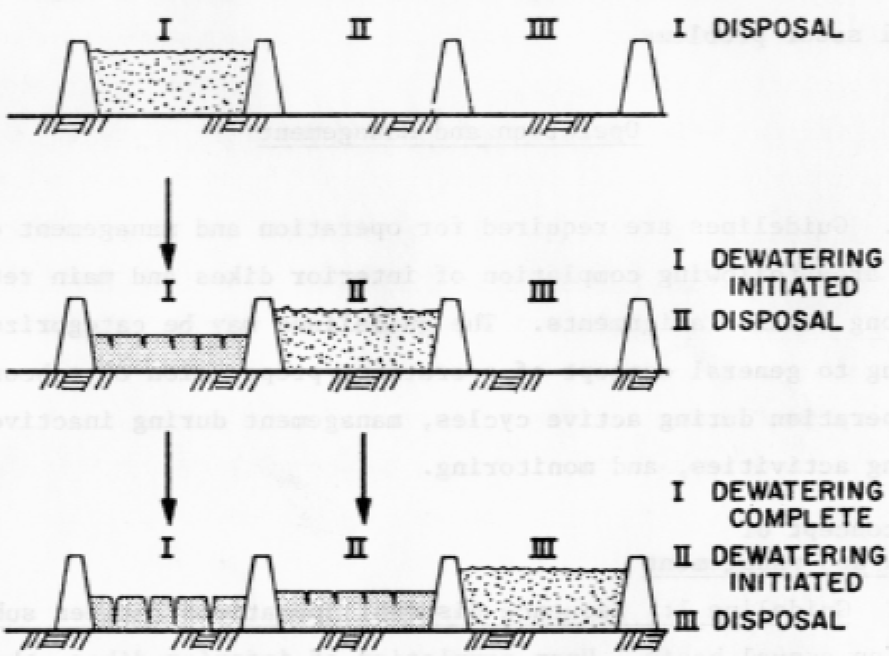


Figure 10. Concept of sequential use of subcontainments

active cycles, ponded water will be maintained within the subcontainment to promote effective sedimentation, thereby ensuring acceptable water quality of effluent (see Guideline 6).

42. Guideline 3: Prevent ponding during inactive cycles. Surface water will be removed and prevented from ponding within the two inactive subcontainments to promote drying and restoration of storage capacity.

Preparation of subcontainments

43. Guideline 4: Upgrade dikes during inactive cycles. During available 2-year inactive cycles, subcontainment dikes should undergo rehabilitation and upgrading in preparation for the next active cycle. This process should be accomplished gradually, using dewatered dredged material available along the dike alignment to the greatest degree possible. Upgrading is best accomplished during the process of periphery trenching (Guideline 13).

44. Guideline 5: Perform necessary preparation of subcontainments. Final inspection of subcontainment dikes and miscellaneous

preparation activities should be accomplished immediately prior to initiation of an active cycle. Preparation activities should include removal of vegetation which might cause short-circuiting in a ponded condition, initial weir boarding to required minimum depth of ponding, and placement of any desired instrumentation for monitoring activities.

Operation during active cycles

45. Guideline 6: Maintain ponding depth along western dike as a function of inflow rate. Ponded depth of water along the western dike should be maintained as a function of inflow rate during the entire active cycle. Since disposal operations occur on a year-round basis, a pond will be maintained in the active subcontainment a majority of the time. The guide curve in Figure 11 should be used to determine required ponding depth along the west dike for a given inflow rate. The guide curve is designed to provide required ponded surface area for the corresponding ponded depth, considering average surface slope within the disposal area; therefore, local depressions caused by trenching or erosion should not be considered when setting the ponding depth. If inflow

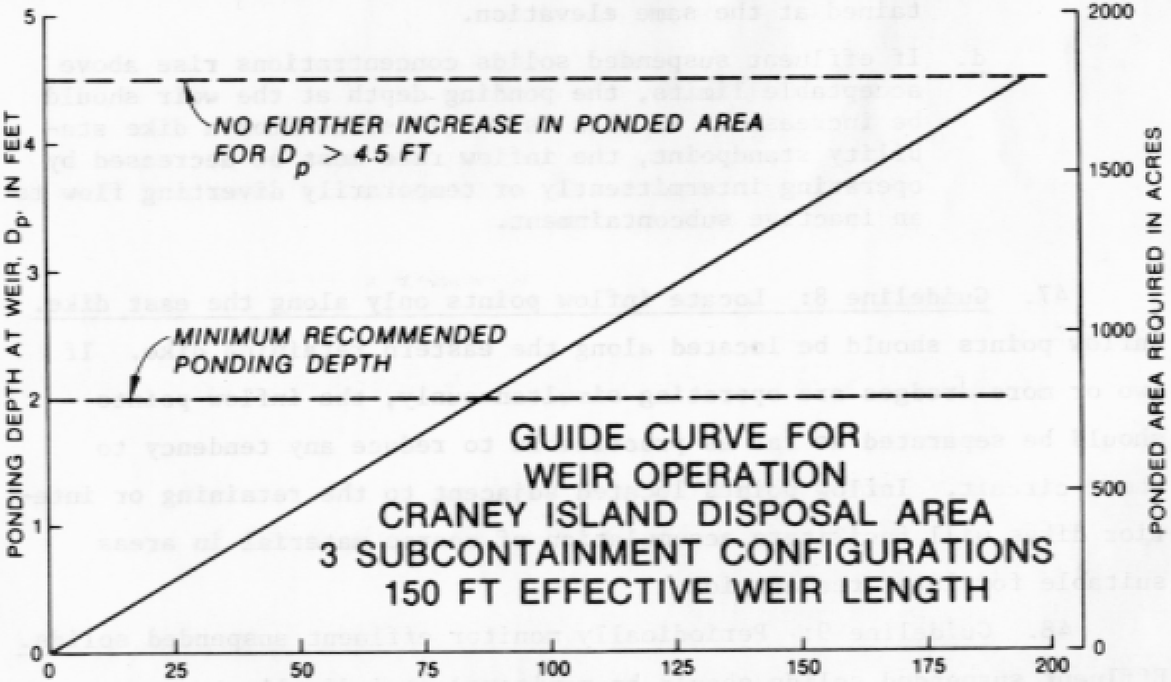


Figure 11. Guide curve for weir operation, 150-ft effective weir length three-subcontainment area configuration

is discontinued for significant periods, the pond should be drawn down in accordance with Guideline 11. A minimum ponding depth of 2 ft is recommended, even though lesser ponding depths may result in sufficient ponded surface areas for settling at low flows. The 2-ft minimum will reduce any tendency to short-circuit and will offset any local variation in surface topography, allowing flow to reach both weirs. The weir boarding will require periodic adjustment as the dredged material surface rises, so that suitable ponding depth is always maintained. The technical basis for this guideline is found in Part IV.

46. Guideline 7: Operate weirs to maintain water quality. Weirs should be operated in accordance with the following general guidelines:

- a. The weir crest elevation should be maintained at the highest feasible elevation to ensure maximum effluent water quality.
- b. Floating debris should be periodically removed from the front of the weir to prevent withdrawal flows at greater depths.
- c. The crest of both weirs in the active subcontainment (assuming that both weirs are operating) should be maintained at the same elevation.
- d. If effluent suspended solids concentrations rise above acceptable limits, the ponding depth at the weir should be increased. If this is not feasible from a dike stability standpoint, the inflow rate must be decreased by operating intermittently or temporarily diverting flow to an inactive subcontainment.

47. Guideline 8: Locate inflow points only along the east dike. Inflow points should be located along the eastern retaining dike. If two or more dredges are operating simultaneously, the inflow points should be separated as far as practicable to reduce any tendency to short-circuit. Inflow points located adjacent to the retaining or interior dikes will facilitate accumulation of coarse material in areas suitable for later reclamation.

48. Guideline 9: Periodically monitor effluent suspended solids. Effluent suspended solids should be monitored periodically to ensure that water quality is being maintained. Indirect indicators of suspended solids concentration, such as visual comparison of effluent

samples with samples of known concentration, should be used on a daily basis. Laboratory determination of effluent suspended solids should be performed on a weekly basis if visual inspection indicates need.

49. Guideline 10: Specify inflow point in the contract and alternate between subcontainments on separate contracts. The alternation between subcontainments, or "switchover," should be planned so as to coincide with initiation of a separate contract item. Points of inflow should be specified in the dredging contracts. The switchover should be planned well in advance based on anticipated duration of contracts and volumes to be dredged unless unusual conditions require a quick change.

Surface water management during inactive cycles

50. Guideline 11: Remove pond following completion of active cycle. Ponded water should be slowly decanted following completion of the active cycle (or if inflow is discontinued for prolonged periods during an active cycle). A row of stoplogs should not be removed until the water level is drawn down to the weir crest and outflow is low. It is desirable to eventually remove stoplogs below the dredged material surface once the material has consolidated and dried sufficiently to prevent flow or excessive erosion. Notched stoplogs may be placed in the final stages to allow slow removal of smaller ponds.

51. Guideline 12: Lower weir crest during inactive cycles as required to prevent ponding. The dredged material surface will subside during inactive cycles due to consolidation/desiccation. Weirs must be periodically checked and stoplogs removed to prevent subsequent ponding during inactive cycles.

Dewatering activities

52. Guideline 13: Construct periphery trenches for initial dewatering. Construction of periphery trenches should be initiated as soon as possible during the initial portion of inactive cycles. The periphery trenches should be constructed adjacent to the subcontainment dikes and should lead to the weir structures (Figure 12). Draglines working from the dikes or on mats adjacent to the dikes are probably best suited for constructing the trenches. Material excavated during

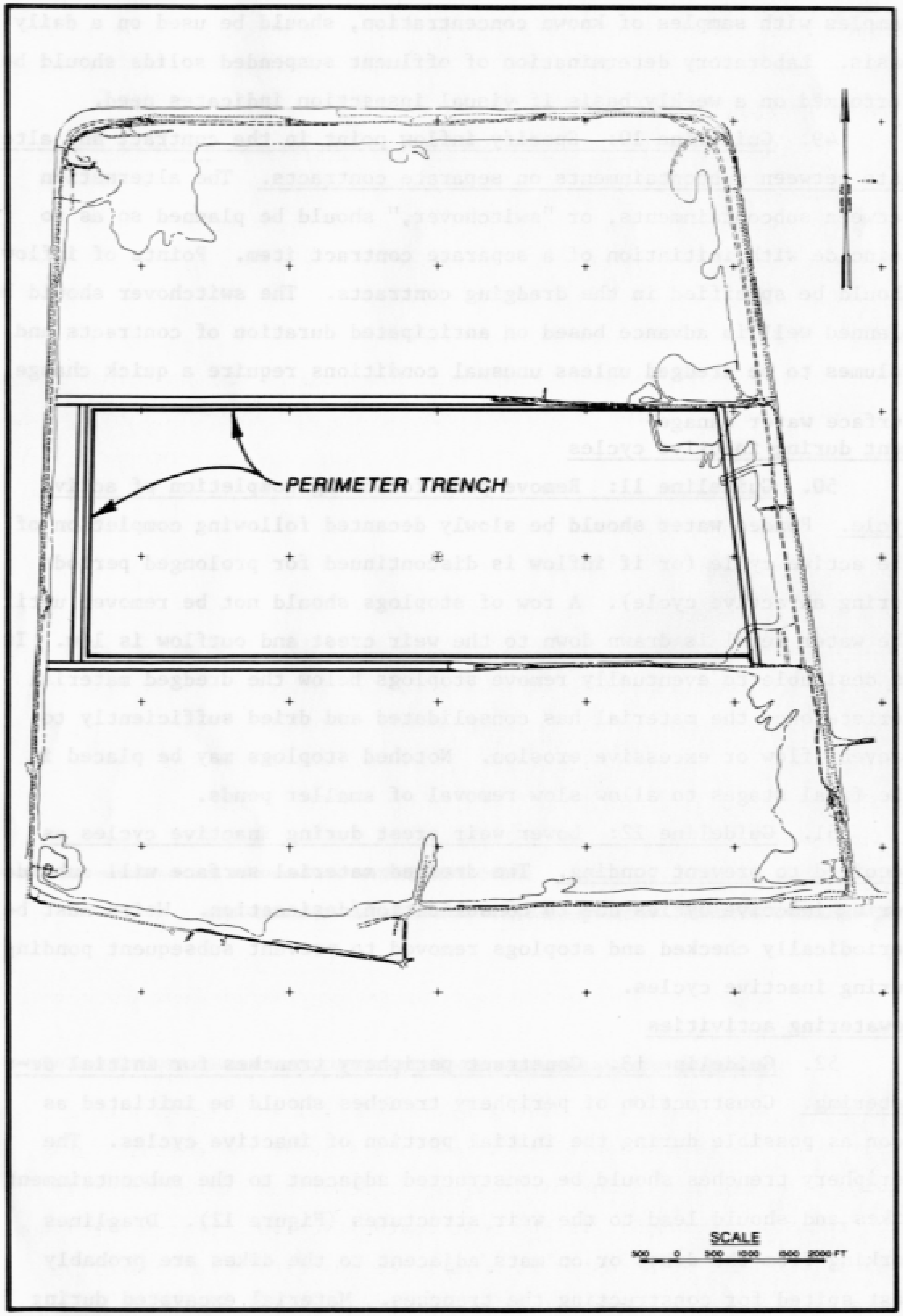


Figure 12. Periphery trench layout for dredged material dewatering

periphery trenching should be directly placed on the dike to raise the dike section or spread between the dike and trench to dry for later use in dike raising (refer to Part VI).

53. Guideline 14: Construct interior trenches for additional dewatering. Once periphery trenches are completed, forming a flowpath to outlet weirs, interior trenching to further increase surface drainage efficiency should be initiated. The interior trenches should be constructed in a V-pattern (Figure 13), taking advantage of the surface slope to drain water toward the periphery trenches. Depending on final equipment selection, a crust thickness of 4 to 6 in. is desirable before interior trenches should be initiated. Rotary trenchers (Figure 14) or draglines mounted on similar amphibious carriers are recommended for interior trench construction. The final equipment selection should be based on field trials.

Monitoring program

54. Guideline 15: Install desired instrumentation during inactive cycles and monitor as required. Instrumentation such as settlement plates or piezometers should be placed during inactive cycles when access to the site interior is possible (Guideline 5). Monitoring of surface subsidence, rates of filling, and groundwater table fluctuations should be accomplished as required to compare field behavior with prior estimates.

Dredged material reclamation

55. Guideline 16: Reclaim and use coarse-grained material. Reclamation of coarse-grained dredged material from areas coinciding with traditional points of inflow should continue on more or less the same volume basis as at the present time. Techniques now used to reclaim this material seem to be the best suited for this particular site. The areas over which suitable coarse-grained material is located are relatively small in comparison with the overall size of the disposal area. Loading of small quantities by dragline or front-end loader directly into trucks for transport is the most cost-effective approach. For some applications, use of scrapers to move large quantities to rehandling points or directly to areas of dike upgrading may be feasible.

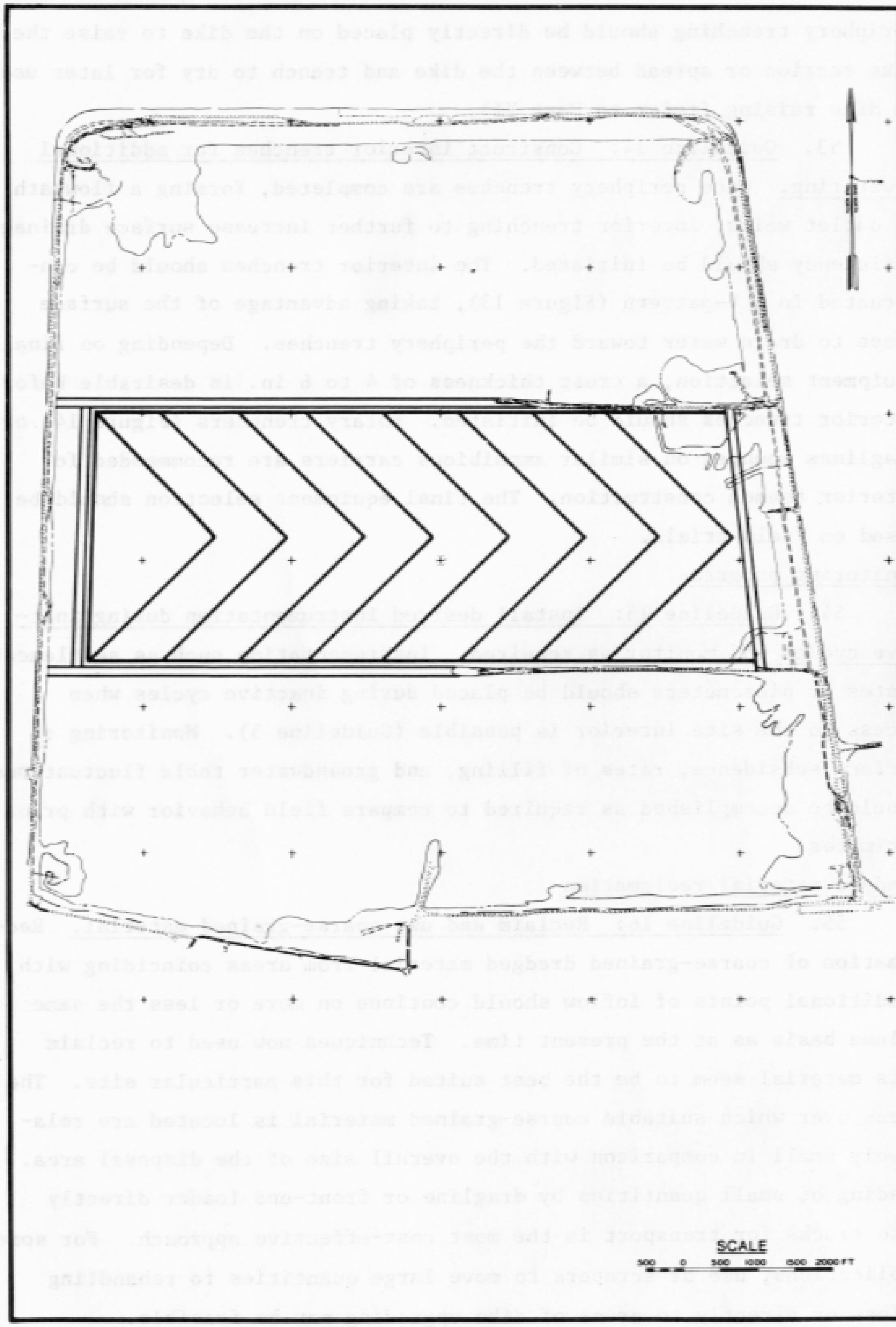
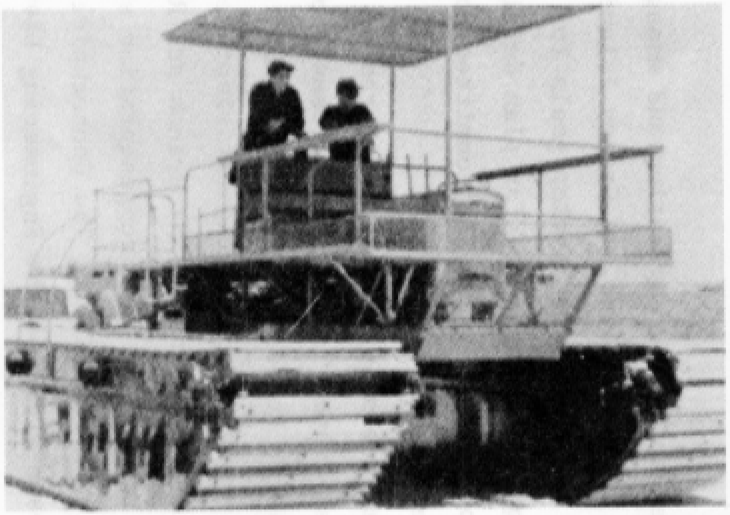
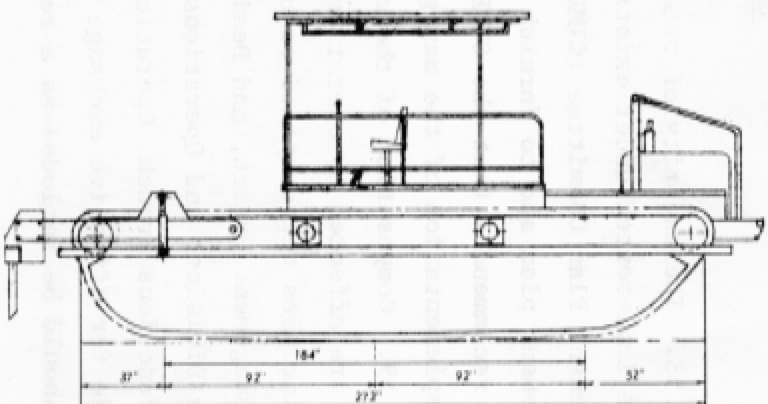


Figure 13. Interior trench layout for dredged material dewatering





Specifications for Vehicle No. III-11

Vehicle Identification: Amphibious Carrier Model 10XT-HD-65M

Vehicle Manufacturer: Quality Marsh International Corp.
P. O. Box 406
Thibodaux, LA 70301

General Data

Weight – Basic:	20,000 lb	Maximum Speed – Land:	4-5 mph
Payload:	12,000 lb	– Water:	3-4 mph
Gross Weight:	32,000 lb	Ground Clearance:	48 in.
Ground Pressure – Empty:	0.91 psi	Fording Depth:	AMP in.
– Loaded:	1.45 psi	Maximum Slope Negotiable:	60 %
Overall – Length:	273 in.	Vehicle Cone Index (1-Pass):	0
– Width:	219 in.	Vehicle Cone Index (50-Pass):	2
– Height:	in.	Track or Tire Size:	60 × 184 in.
Grouser Height:	<1.5 in.		
Sprocket Pitch:	2 in.	Tire Pressure:	NA psi
Number of Roadwheels or Bogies per Side:	4		

Mechanical Components Data

Engine –

Standard: Ford, 256 CID, 4 cylinder, 82 BHP

Optional: Ford, 380 CID, 120 BHP, GM 3-53 diesel, 78 BHP

Transmission –

Main: 4 speed manual

Optional: None

Auxiliary:

Suspension: Rigid

Tracks or Wheels: Three strands of heavy-duty track chain with 4-in. aluminum cleats

Miscellaneous

Primary Use: Personnel or cargo carrier

Cost: $18,047

Potential Uses: Mount for push blade, pull plow, drill rig, or roto boom.

Available: Yes

Figure 14. Schematic and specifications for rotary trencher (after EM 1110-2-5000, Office, Chief of Engineers, Department of the Army 1978)

56. As the retaining dikes and interior dikes are upgraded, the onsite requirements for coarse-grained material will increase. It may therefore be assumed that a majority of accumulated coarse-grained material will be productively utilized in dike upgrading and maintenance activities. Sale and removal of excess coarse-grained material offsite should continue at approximately the present rate.

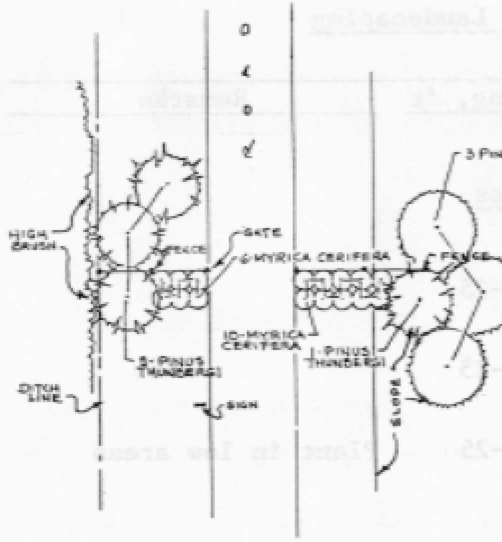
Landscaping

57. Guideline 17: Perform desired landscaping activities as retaining dike is upgraded. Landscaping at the entrance gate locations and along the exterior face of the main retaining dikes should be completed as the main retaining dikes are upgraded. "Diamond" type plantings as indicated in Figure 15 and Table 2 would provide visual shielding with both low- and high-growth vegetation. Artist's conceptions of the appearance of the overall site (Figure 16) and of the retaining dike from water level (Figure 17) show how an effective landscaping plan would serve to reduce objections from local residents to continued use of the site.

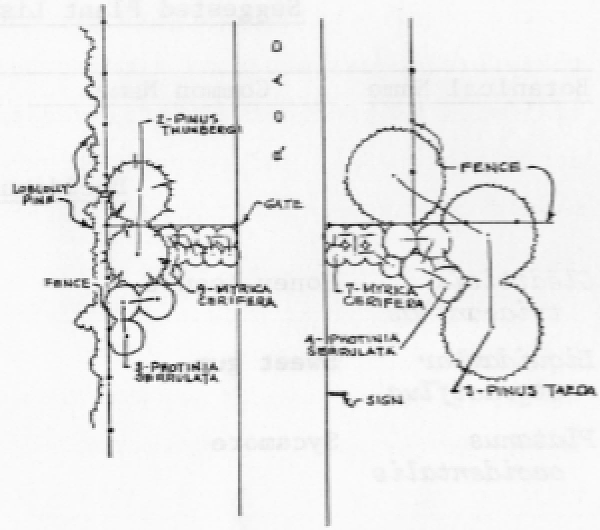
Implementation

58. The majority of recommendations for operation and management can be implemented under existing authorizations. A Craney Island Management Plan Committee (CIMPC) was formed to develop goals for the management plan and to furnish required information for plan development. It is recommended that the CIMPC be left as an ad hoc committee to oversee implementation of the management plan.

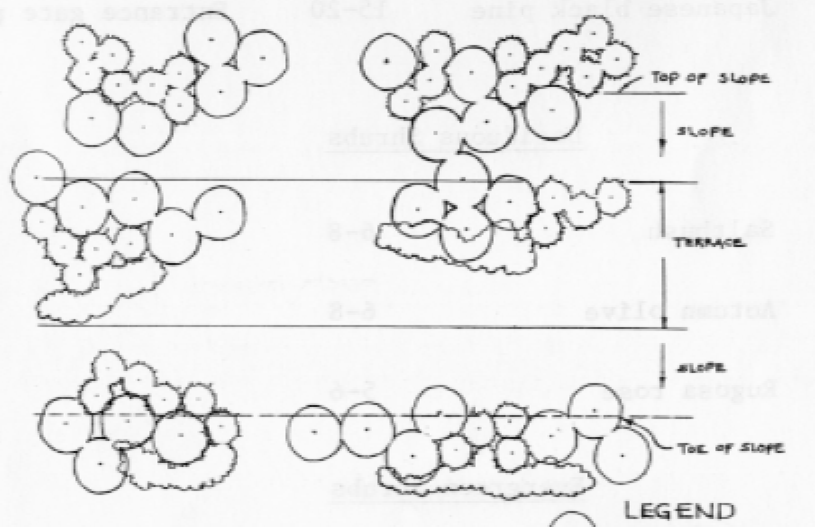
59. Composition of the committee should reflect interested areas which are affected by operations at Craney Island. The present composition includes representatives of Water Resources Planning Branch, Dredging Management Branch, and Design Branch, Engineering Division; Real Estate Division; and Operations and Maintenance (O&M) Branch and Regulatory Functions Branch, Operations Division. This representation should provide for effective exchange between Divisions. The Geotechnical Section should be included as a representative of the Engineering Division.



a. East gate planting plan



b. South gate planting plan



c. Typical slope planting

Figure 15. Plantings for landscape activities

Table 2

Suggested Plant List for Landscaping

Botanical Name	Common Name	Spacing, ft	Remarks
	Deciduous Trees		
Gleditisia triacanthos	Honey locust	20–25	
Liquidambar styraciflua	Sweet gum	20–25	
Platanus occidentalis	Sycamore	20–25	Plant in low areas
	Evergreen Trees		
Juniperus virginiana	Eastern red cedar	15–20	
Pinus taeda	Loblolly pine	15–20	
Pinus thunbergi	Japanese black pine	15–20	Entrance gate plantings
	Deciduous Shrubs		
Baccharis halimifolia	Saltbush	6–8	
Elaeagnus umbellata	Autumn olive	6–8	
Rosa rugosa	Rugosa rose	5–6	
	Evergreen Shrubs		
Myrica cerifera	Southern wax myrtle	5–6	Maintain at 3 ft at gate planting
Photinia serrulata	Chinese photinia	6–8	Entrance gate plantings

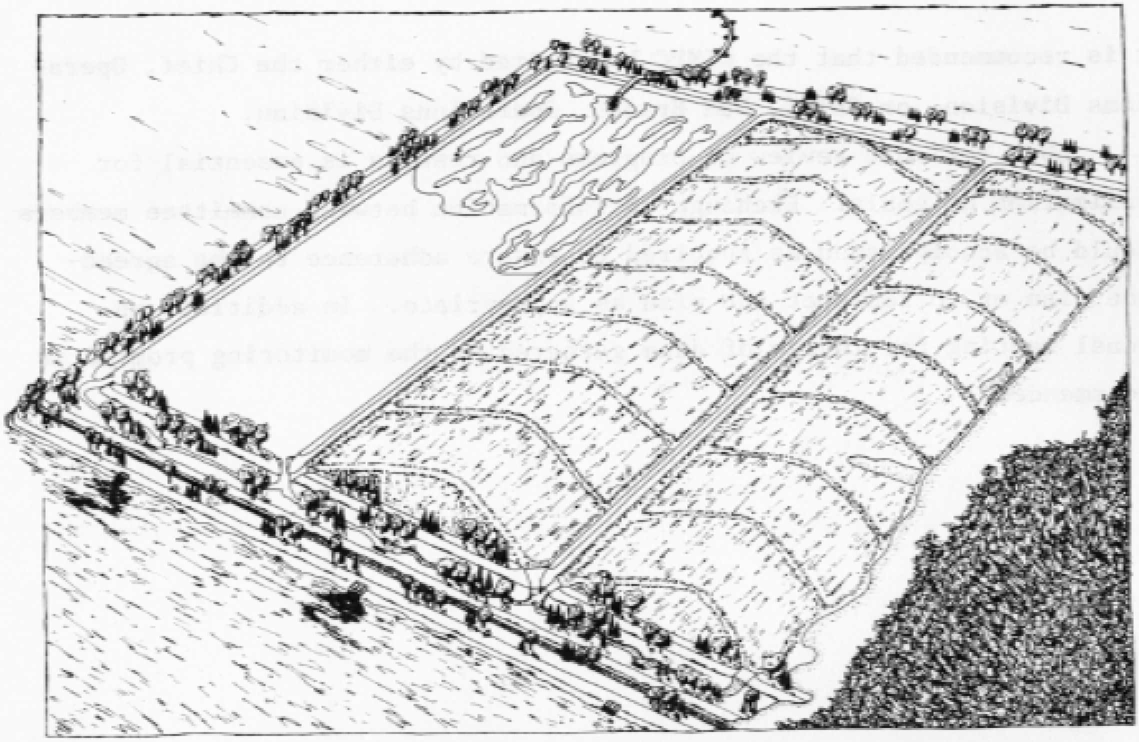


Figure 16. Artist's conception of overall appearance of Craney Island disposal area, showing alternation of disposal operations, interior trenching, and landscaped dikes

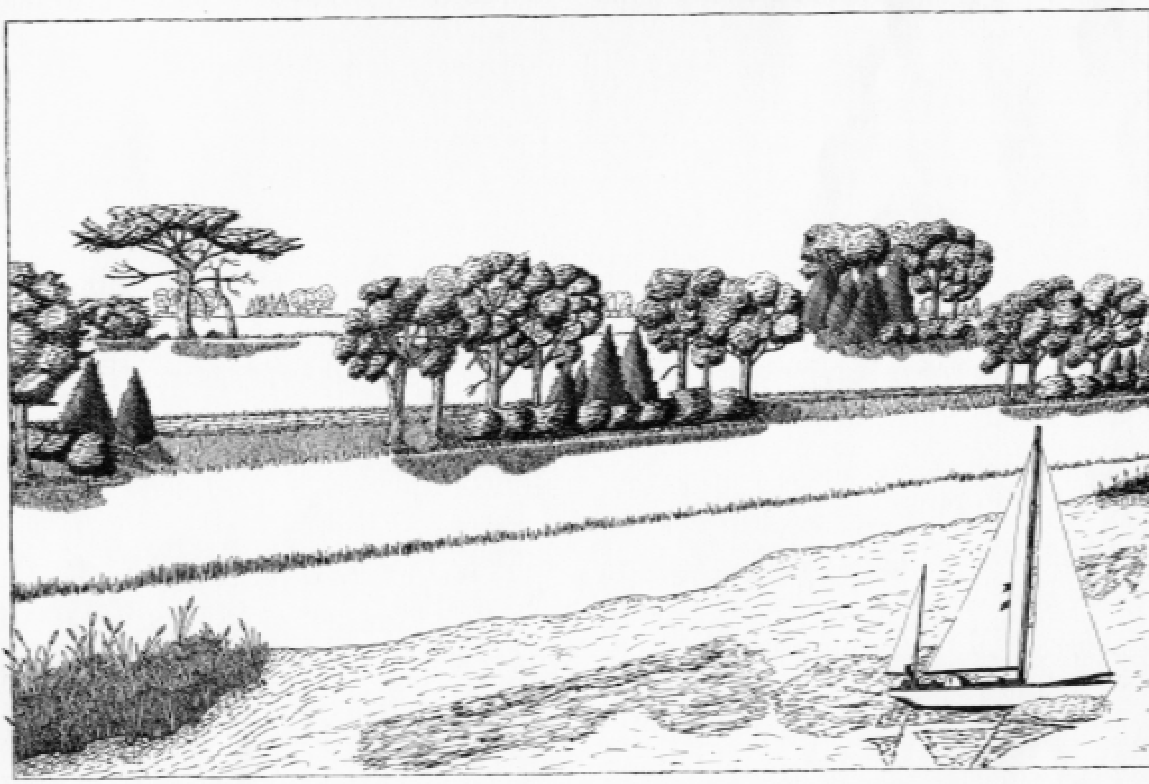


Figure 17. Artist's conception of landscaped dikes from the water level

It is recommended that the CIMPC be chaired by either the Chief, Operations Division, or Chief, O&M Branch, Operations Division.

60. Periodic review of progress and results is essential for realization of goals. Exchange of information between committee members should be accomplished as required to ensure adherence to the agreed-upon plan or to redirect the plan as appropriate. In addition, an annual meeting for review of data gathered by the monitoring program is recommended.

PART II: DISPOSAL SITE CHARACTERISTICS AND DREDGING ACTIVITIES TO DATE

61. This section of the report describes information concerning disposal site characteristics and dredging activities considered pertinent to development of the management plan. The information was largely developed from past records and literature. Where required, data were developed from additional field investigations and laboratory tests described in Part III.

Sources of Dredged Material

General

62. Sources of the majority of dredged material placed within the Craney Island disposal area are listed and described in Table 3. Areas of Federal maintenance responsibility are shown in Figure 18. These sources mainly comprise the Federal navigation channels and adjacent anchorages and slips associated with the Norfolk Harbor.

Distribution of sediments by type

63. A geological study of the sediments of the James River estuary (Nichols 1972) contains a general description of the sediment transport and deposition patterns for the estuary. This study concluded that clay sediments predominate throughout the estuary. However, little detailed information on the engineering characteristics of in situ sediment was available.

64. Hydraulic model studies conducted by WES (Boland and Bobb 1969) indicated that the major source of sediment moving into and depositing in the Elizabeth River channel area (45-ft channel and adjacent slips) was the shallow water area between Craney Island disposal area and the Newport News channel. This indicates that maintenance materials within the Newport News anchorage and channel, the Sewells Point anchorage, and the northern portions of Norfolk Harbor 45-ft channel and adjacent slips would be of similar characteristics.

Table 3

Sources for Dredged Material Placed in Craney Island Disposal Area

Source	Description
Corps of Engineers:	
Norfolk Harbor	Includes material dredged from both the 40- and 45-ft channels generally extending from Sewells Point anchorage upstream (south) to the N&PBL railroad bridge
Sewells Point	Includes material dredged from Sewells Point anchorage
Newport News	Includes material dredged from Newport News anchorage and Newport News channel extending to Sewells Point anchorage
Rehandling Basin	Includes material dredged from Craney Island Rehandling Basin
Southern Branch	Includes a portion of material dredged from 35-ft channel upstream (south) of the N&PBL railroad bridge
Miscellaneous	Includes material dredged from the Federal channels under small contracts
Other:	
Navy Department	Includes material dredged from areas east of Norfolk Harbor 45-ft channel into slips located along the Naval Yard
Private permit	Includes material dredged from slips located south of Craney Island along eastern side of the channel and slips north of Newport News anchorage

Note: Locations for the various source areas are shown in Figure 18.

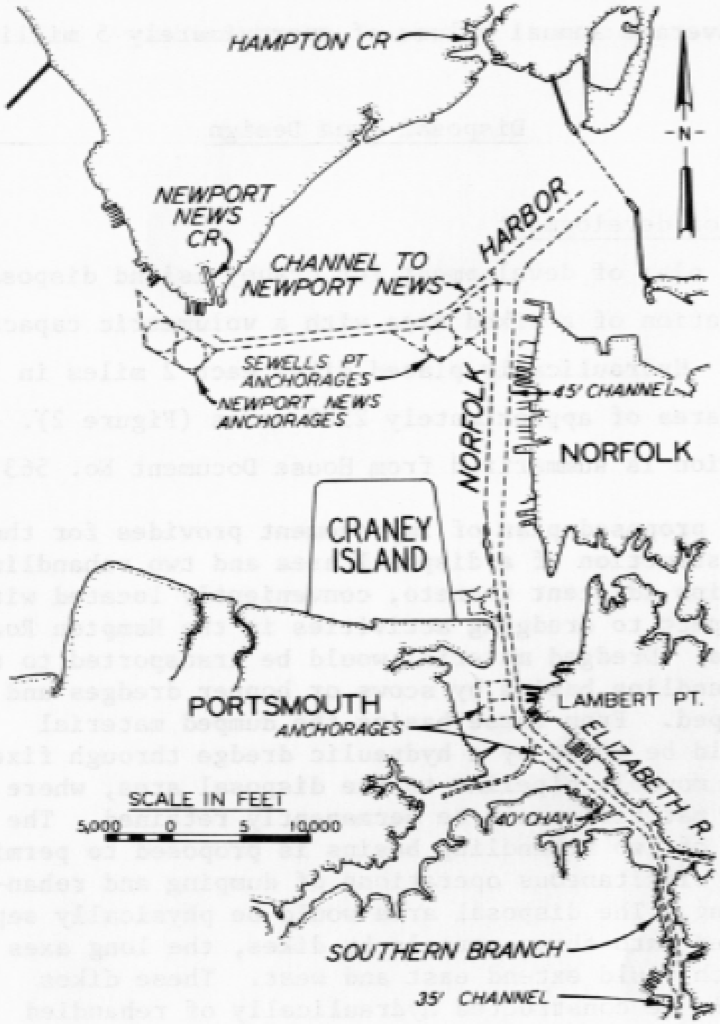


Figure 18. Channels and anchorages comprising area of Corps of Engineers maintenance responsibility

Shoaling rates

65. Estimates of the volume of channel sediments placed in Craney Island on an annual basis are best developed from past records. In general, maintenance requirements are increasing due to periodic deepening and widening of the navigation channels and anchorages. In 1974, the annual maintenance requirement for Norfolk Harbor was an estimated 3.8 million cu yd (Norfolk District 1974). An updated projection of maintenance requirements through 1992 was developed by the Norfolk

District for this study and is summarized in Table 1. This projection indicates an average annual volume of approximately 5 million cu yd.

Disposal Area Design

Original plan of development

66. The plan of development for Craney Island disposal area called for creation of a diked area with a volumetric capacity of 100 million cu yd. Hydraulically placed dikes each 2 miles in length formed a trapezoidal area of approximately 2500 acres (Figure 2). The proposed mode of operation is summarized from House Document No. 563:

> The proposed plan of improvement provides for the construction of a disposal area and two rehandling basins adjacent thereto, conveniently located with respect to dredging activities in the Hampton Roads area. Dredged material would be transported to the rehandling basins by scows or hopper dredges and dumped. From these basins the dumped material would be moved by a hydraulic dredge through fixed and movable pipeline to the disposal area, where the material would be permanently retained. The use of two rehandling basins is proposed to permit the simultaneous operations of dumping and rehandling. The disposal area would be physically separated into three parcels by dikes, the long axes of which would extend east and west. These dikes would be constructed hydraulically of rehandled material. Thereafter, disposal of the rehandled material would be initially made in the parcel farthest from shore. When these deposits reach an elevation of approximately +6.0, disposal would be shifted to the center parcel, et seq. Three sluiceways would be constructed simultaneously with the main levee construction, and their operation would begin with the first deposits of the rehandled material.

67. The disposal area is not now being operated strictly according to the proposed plan. Interior dikes were not completed by hydraulic dredge, but are now being gradually constructed by end-dumping. Also, disposal is ongoing in all three "parcels" in accordance with the minimum pumping distance from various source areas.

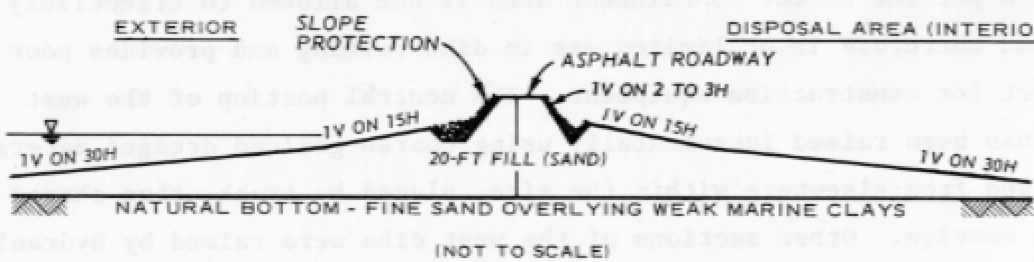
Engineering design

68. Engineering design of the disposal area emphasized foundation analyses for dike stability and settlement (Norfolk District 1953). A wealth of soils data was accumulated for the original design, including consolidation data for compressible foundation soils. Only bulking factors were then available for estimating future storage capacity, and original design projected the area to be filled to el +18.0 ft in 20 years.

Dike Construction

Main retaining dikes

69. A typical cross section of the main retaining dike as initially constructed is shown in Figure 19. The dike was constructed of hydraulic sand fill placed below the water surface and topped with a clamshell-constructed central section reaching a height of 8 ft above the water surface. Trenches from the clamshell excavation were left in the hydraulic fill on either side of the central section. These trenches were later filled with stone to serve as the toe of the riprap protection as shown in Figure 19. On several occasions, the hydraulic fill generated mud waves ahead of construction caused by displacement



NOTE: MAXIMUM WATER DEPTH ALONG THE DIKE ALIGNMENT IS 12 FT.

EXTERIOR SLOPE PROTECTION – RIPRAP, 24 IN. THICK WITH A NOMINAL STONE SIZE OF 1000 LB. BEDDING LAYER, 9-IN.-THICK CRUSHED ROCK.

INTERIOR SLOPE – RIPRAP, 12 IN. THICK WITH A NOMINAL STONE SIZE OF 200 LB. BEDDING LAYER, 9-IN.-THICK CRUSHED ROCK.

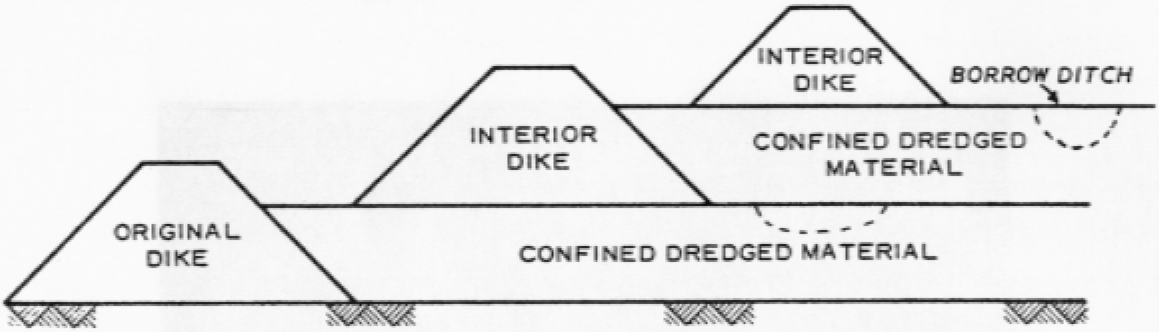
Figure 19. Craney Island retaining dike as initially constructed

of the underlying weak clays. These waves had to be removed before construction could continue. The mud wave problem was solved by distributing the fill more evenly with a floating swing discharge line (Horn 1969; Murphy and Ziegler 1974).

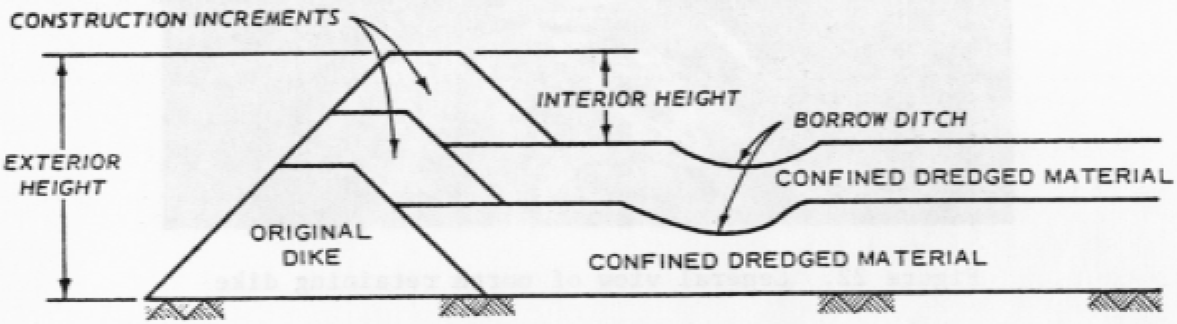
70. Since their initial construction, the main retaining dikes have generally been raised by constructing interior dike sections stepped or benched in at a distance of 250 ft. These higher dike sections were constructed by dragline using dredged material taken from within the disposal area (see conceptual illustration in Figure 20 and photo in Figure 21).

71. The stepped method of dike raising has been used successfully only on the north and east dikes. Material adjacent to the dike along these reaches is exposed to drying periodically and could be pulled up successfully to form the section. Also, partially dry material in these reaches could better support equipment, allowing the benched section to be constructed well toward the site interior. A general view of the north dike is shown in Figure 22.

72. Conditions along the west levee dictated that an incremental dike raising technique be employed as shown conceptually in Figure 20b. The west end of the site is of lower elevation, and, in this area, water sometimes remains ponded for extended periods. Dredged material in the western portion of the containment area is not allowed to effectively dry and therefore is of limited use in dike raising and provides poor support for construction equipment. The central portion of the west dike has been raised incrementally using coarse-grained dredged material borrowed from elsewhere within the site, placed by truck, then shaped to final section. Other sections of the west dike were raised by hydraulic placement of new work material or by draglines pulling up adjacent coarse-grained material. The west dike is considered to be the weakest of the retaining dikes since the raised section could not be stepped far toward the site interior. Almost a continuous upgrading of the west dike is necessary to maintain the required height. A general view of the west dike is shown in Figure 23.



a. Concept of stepped dike construction method



b. Concept of incremental dike construction method

Figure 20. Concepts of stepped and incremental dike construction methods

Figure 21. Dragline construction of stepped dike section

Figure 22. General view of north retaining dike

Figure 23. General view of west retaining dike

Interior dikes

73. Two interior dikes, as proposed in the original plan of development, have been partially constructed east to west across the interior of the disposal area. Construction has largely been accomplished at a slow rate, as resources would allow. Initially, the interior dikes were built by hydraulic placement along the alignment. Draglines pulled up the material, and coarse-grained material was end-dumped to raise the section and to displace softer fine-grained material as the section progressed. Draglines have been used to pull upadjacent material to further raise the section. Recently, debris, consisting mostly of discarded timbers, has been end-dumped in advance of the section, forming a wide base. Coarse-grained material is then trucked and end-dumped as a cover to form the dike section. In this manner, the interior dikes are "floated" as the underlying materials become softer toward the center of the disposal area. General views of the interior dike sections are shown in Figures 24 and 25.

Figure 24. General view of north interior dike

Disposal Operations

Records

74. Operation of the Craney Island disposal area has been well

Figure 25. General view of south interior dike

documented since its initial construction. Records of yardages dredged, locations, time of disposal, method of disposal, etc., have been maintained by the Norfolk District for each dredging contract involving disposal into the Craney Island facility. This record is reproduced in Appendix A. An illustration of the duration and sequence of operations is summarized in Figure 26.

Dredging equipment

75. A brief description of dredging equipment used in disposal operations of the Craney Island facility is taken from Norfolk District (1974):

> Dredging in Hampton Roads is carried out by three basic types of dredging plants. These are (1) the hopper dredge, (2) the hydraulic pipeline dredge, and (3) the bucket dredge. Each dredging system has its distinctive operational characteristics. Which is selected depends on the type of material to be dredged, location of disposal areas, weather and sea conditions, and vessel traffic patterns within the harbor.
>
> Over the years, most of the maintenance and new work dredging of the Channel to Newport News and

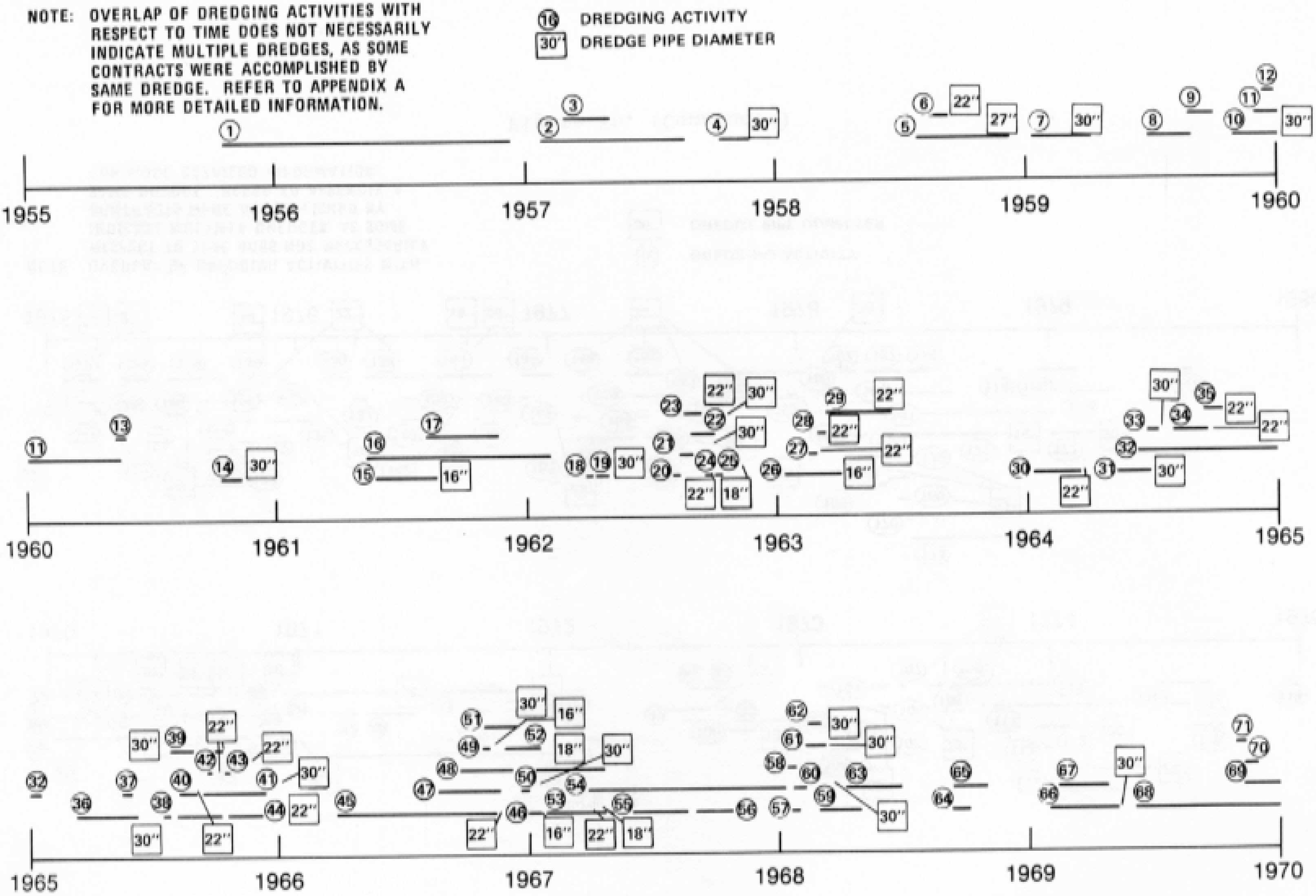


Figure 26. Summary of dredging operations 1957-1979 (Continued)

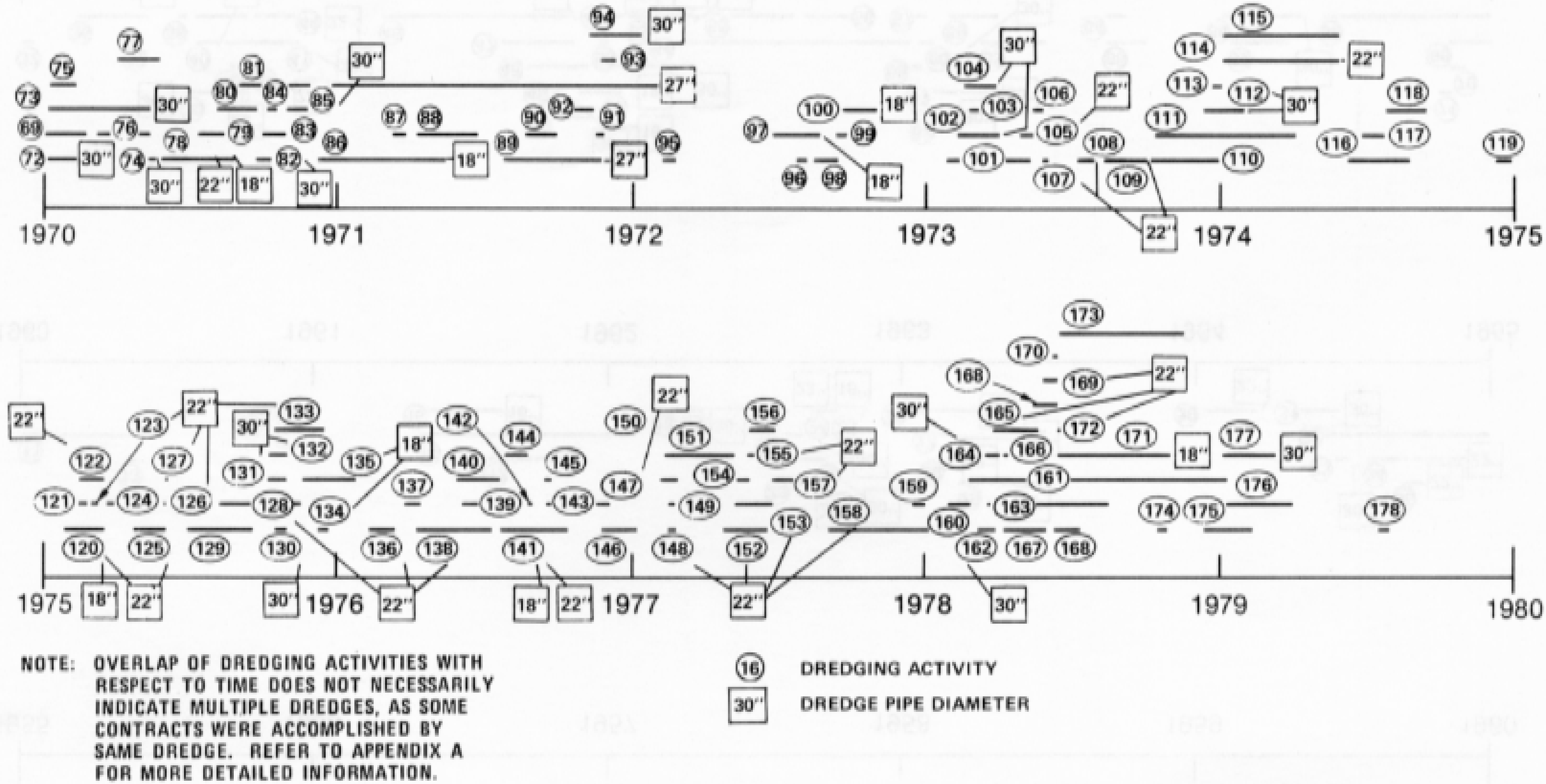


Figure 26. (Concluded)

the Norfolk Harbor Channel has been accomplished by Federally-owned hopper dredge. In the last 20 years, increasingly large quantities of material have been dredged by hydraulic pipeline dredge. Most of this work has taken place when hopper dredges would have been more costly to operate, such as while dredging anchorage areas or accomplishing new work in main channels having nearby disposal sites. Jobs involving small quantities of dredging or working in relatively constricted areas continue to be accomplished by bucket dredge.

76. Pipeline diameters of dredges used for some dredging contracts were available from past records and are also indicated in Figure 26. Based on these past records the maximum inflow rate into the disposal area was approximately 130 cfs resulting from a combination of four dredges.

Points of inflow

77. A major consideration in determining the point of inflow for all dredging operations to date has been proximity to the area dredged. Also, consideration is given to type of dredging, i.e. pipeline discharge, hopper pumpout, and rehandling basin dredging. Preferred points of inflow based on these considerations as related to source of material are summarized in Table 4. The points of inflow are illustrated in Figure 27. In general, the majority of material deposited directly by pipeline is placed at point B, direct pumpout of hopper dredges is placed at point E, and pumpout from the rehandling basin is placed at point C.

78. Volumes of material as related to preferred point of inflow were developed from information in Tables 1 and 4. A recapitulation of projected dredging volumes as related to preferred points of inflow is summarized in Table 5. This summary indicates that the majority of material is now deposited at points B and E along the eastern side of the disposal area.

Disposal operations

79. A majority of material is placed within the disposal area from the eastern dike, causing a general slope toward the outlet structures located along the western dike. Coarse-grained material falls

Table 4

Percentage of Dredged Volumes Related to Preferred Points of Inflow

Source	Point of Inflow (See Figure 27) B	C	D	E	F	Total
Corps of Engineers:						
Norfolk Harbor	70			30		100
Sewells Point	100					100
Newport News			100			100
Rehandling Basin		100				100
Southern Branch				100		100
Miscellaneous contracts	40			40	20	100
Other:						
Navy Department	70			30		100
Private permit	50			50		100

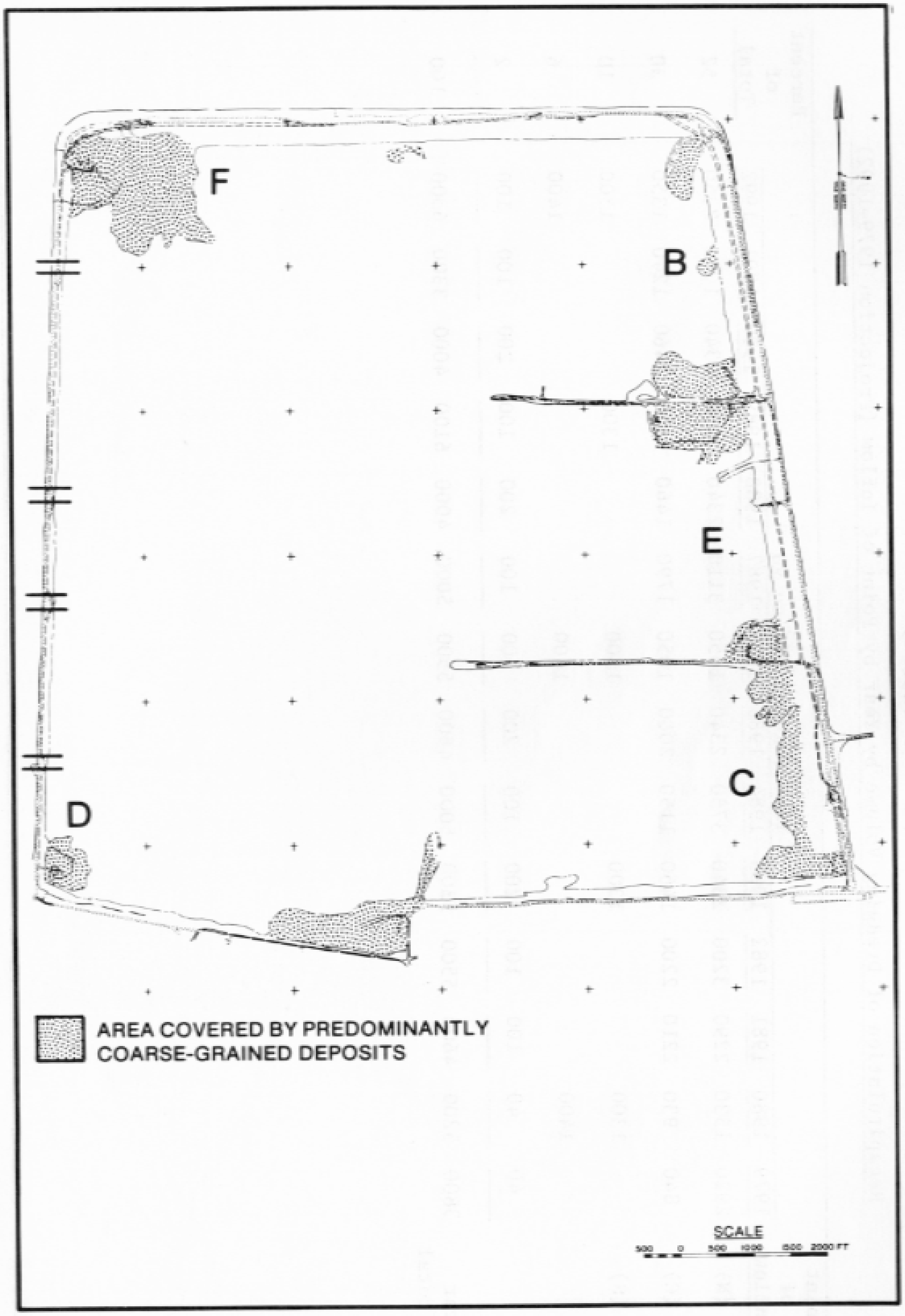


Figure 27. Areas of accumulated coarse-grained material corresponding to points of inflow

Table 5

Recapitulation of Dredging Volume by Year by Point of Inflow (Projection 1979-1992)

Point of Inflow	Year-Volume, 10^3 cu yd														Percent of Total
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	
B (N)	2920	1530	2290	3200	2340	3750	2340	1650	3110	2340	3250	2340	1960	2350	52
E (C)	840	930	2210	2200	1460	1150	2060	1050	1790	1460	1450	1460	1240	1350	30
C (S)		1300			1300			1300			1300			1300	10
D		1400						1400						1400	6
F	40	40	100	100	200	100	200	100	100	200	100	200	100	100	2
Year total	3800	5200	4600	5500	5300	5000	4600	5500	5000	4000	6100	4000	3300	6500	100

from suspension quickly and accumulates near the points of inflow. In this manner, areas covered by coarse-grained material have developed at each of these points of inflow as indicated in Figure 27. Coarse material varies from shell, as shown in Figure 28, to sands.

80. During disposal, a sheet flow condition develops until the dredged material slurry reaches the area of ponding. Some channelization is evident as fine-grained material moves toward the outlet structures, and the path of flow tends to shift laterally as material is deposited. Truly ponded conditions extend only over the western portion of the area of flow, varying between 20 and 50 percent of the total diked area. Depths of ponding are now normally kept as small as possible to prevent excessive wave heights and still maintain adequate water quality of effluent. The fine-grained dredged material is deposited in relatively thin lifts. A typical inflow is shown in Figure 29.

81. The partially completed spur dikes or interior dikes now serve to separate flow when two or more dredges are operating simultaneously. This practice tends to somewhat reduce the tendency for the sheet flow to channelize (Murphy and Ziegler 1974). The spur dikes also serve to reduce effective fetch distances and minimize wind effects.

82. Two or more weir structures of the four available may be in operation for any respective disposal operation, depending upon the point(s) of inflow and existing topography conditions along the western dike. Weirs are normally selected for operation which create the longest flow distance possible and, consequently, the largest possible area of ponding. This practice is illustrated in the aerial photo in Figure 1. Even with some channelization occurring and small ponding depths, acceptable water quality of effluent is maintained due to the very large area ponded during disposal operations.

Topographic surveys

83. Surveys have been made periodically over the entire disposal area or selected portions, providing a check on the surface area elevations and rate of filling. The surveys were performed using a combination of land survey techniques, hydrographic techniques (from boats operating within the disposal area), and aerial techniques. Topographic

Figure 28. Coarse-grained material accumulated at point of inflow F

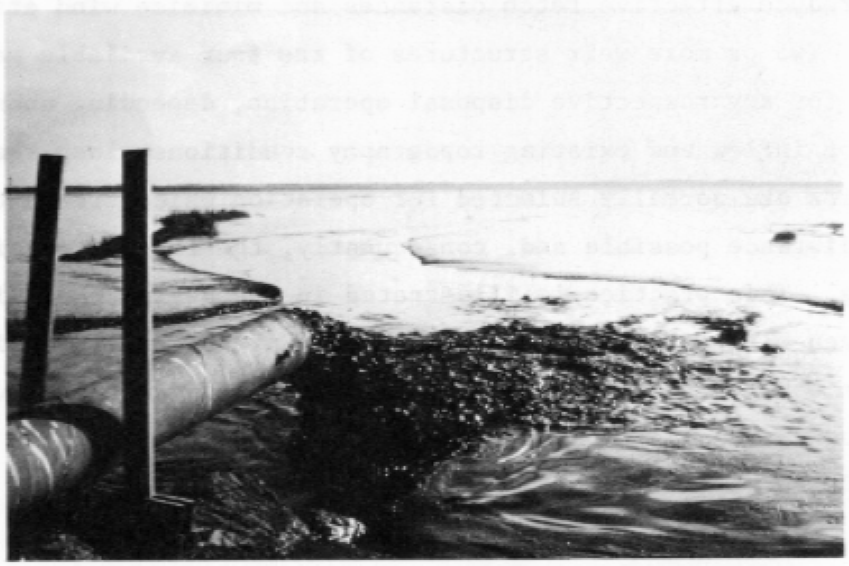


Figure 29. Typical point of inflow

information was developed from these surveys and is contained in Appendix B. Figure 30 is a typical section showing accumulation of dredged

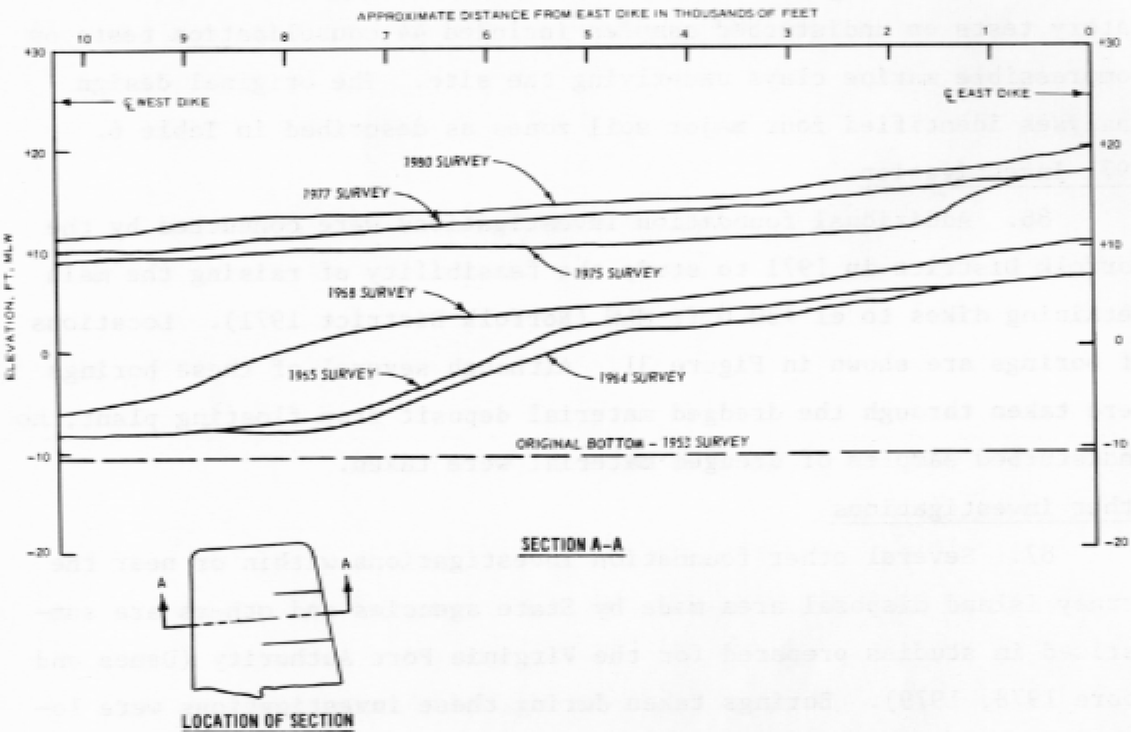


Figure 30. Typical section illustrating the accumulation of dredged material within the disposal area

material within the disposal area. As can be seen in this figure, the fine-grained material maintained a steeper slope below the mean low water level. As material rose above the water, an average slope of approximately 5 ft in 10,000 ft was maintained in an east to west direction.

Foundation Investigations

84. This subsection describes conditions for those foundation soils lying below the dredged material deposit within Craney Island. Information regarding engineering properties of dredged material obtained as part of this study is described in Part III.

1953 investigation

85. As extensive investigation of foundation conditions was

conducted by the Norfolk District as the major portion of the original disposal area design (Norfolk District 1953). A total of 11 undisturbed borings and a large number of general sample borings were taken. Laboratory tests on undisturbed samples included 44 consolidation tests on compressible marine clays underlying the site. The original design analyses identified four major soil zones as described in Table 6.

1971 investigation

86. Additional foundation investigations were conducted by the Norfolk District in 1971 to study the feasibility of raising the main retaining dikes to el +30.0 ft MLW (Norfolk District 1971). Locations of borings are shown in Figure 31. Although several of these borings were taken through the dredged material deposit from floating plant, no undisturbed samples of dredged material were taken.

Other investigations

87. Several other foundation investigations within or near the Craney Island disposal area made by State agencies and others are summarized in studies prepared for the Virginia Port Authority (Dames and Moore 1978, 1979). Borings taken during these investigations were located in areas of coarse deposits and did not provide information regarding engineering properties of the fine-grained dredged material.

Foundation conditions

88. Results of all foundation borings were examined and generalized foundation conditions were developed as shown in Figure 32. A thick deposit of marine clay (CH) generally underlies the present dredged material deposit. The thickness of this clay deposit gradually increases for the first few thousand feet from the shoreline, then sharply increases to a thickness of approximately 90 ft under the remainder of the area. This variation in thickness is substantiated by similar variation in dike settlement rates (Norfolk District 1971). The marine clay layer is underlain by stiff sands and silty sands.

Table 6

Major Foundation Soil Zones

Zone	Soil Type	Elevation ft MLW From	Elevation ft MLW To	Natural Densities lb/ft^3 Dry	Natural Densities lb/ft^3 Submerged
A	Grey marine clay	-10	-30	48.8	29.3
B	Grey marine clay	-30	-60	49.7	30.1
C	Marine clay, some silt	-60	-90	57.1	34.3
D	Clay and silt, some sand	-90	-110	60.3	39.9
Below D	Hard compact sand	Below -110		--	--

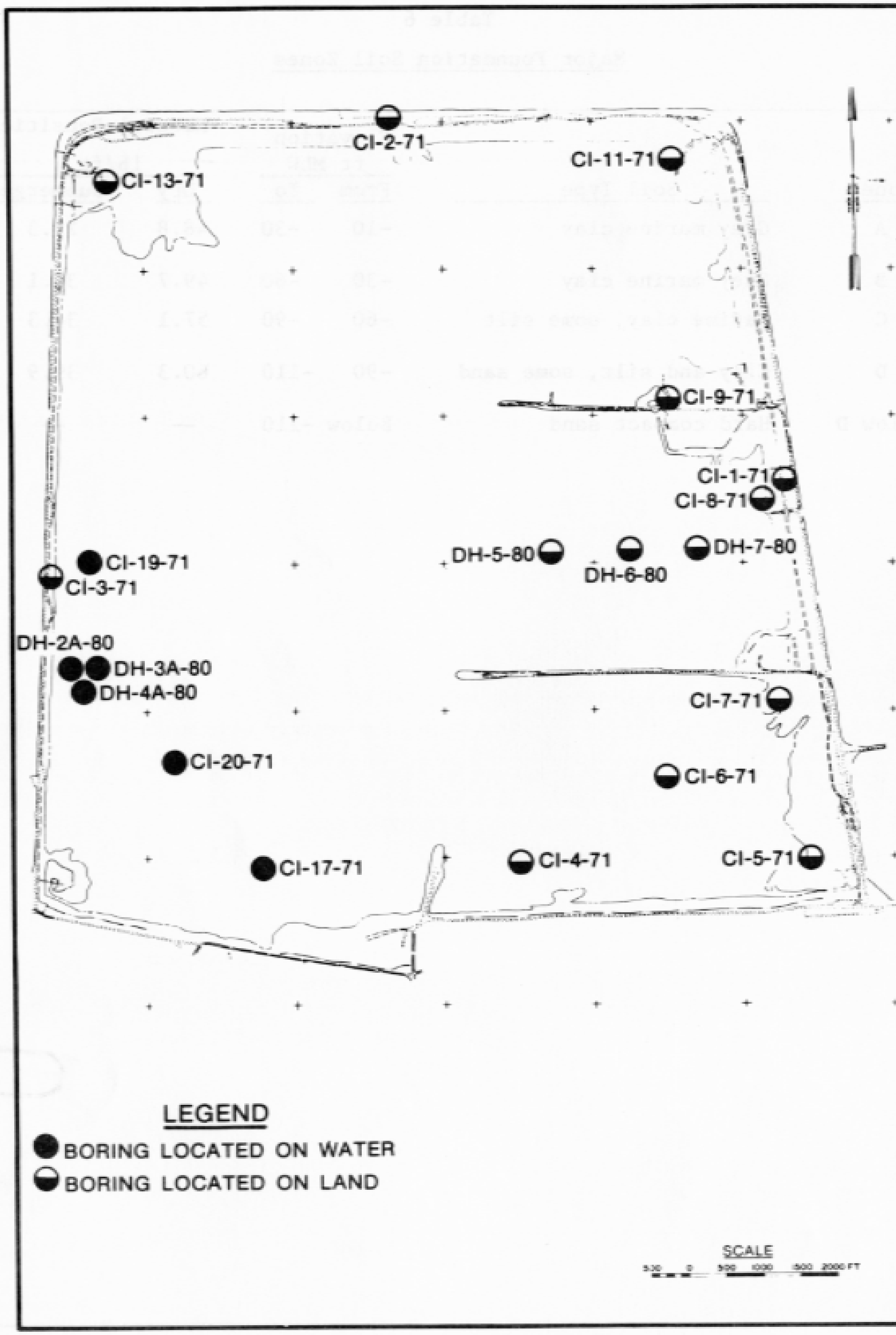


Figure 31. Boring plan

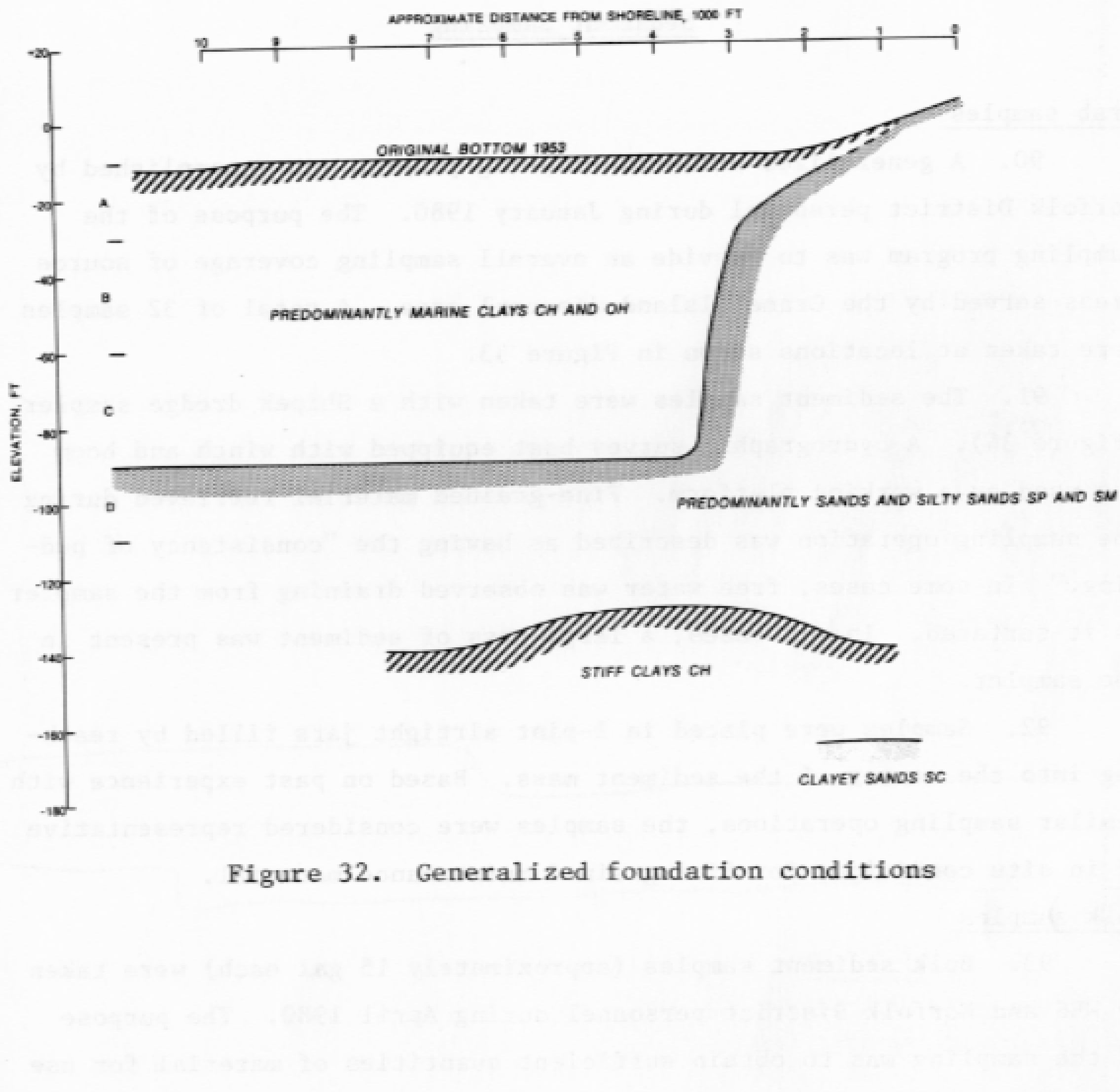


Figure 32. Generalized foundation conditions

PART III: FIELD AND LABORATORY INVESTIGATIONS

89. This part of the report describes field investigations and laboratory tests which were performed to provide required data not available from past records. The investigations and tests were performed in accordance with procedures recommended in TR DS-78-10 (Palermo, Montgomery, and Poindexter 1978).

Sediment Sampling

Grab samples

90. A generalized sediment sampling program was accomplished by Norfolk District personnel during January 1980. The purpose of the sampling program was to provide an overall sampling coverage of source areas served by the Craney Island disposal area. A total of 32 samples were taken at locations shown in Figure 33.

91. The sediment samples were taken with a Shipek dredge sampler (Figure 34). A hydrographic survey boat equipped with winch and boom was used as a working platform. Fine-grained material retrieved during the sampling operation was described as having the "consistency of pudding." In some cases, free water was observed draining from the sampler as it surfaced. In all cases, a large mass of sediment was present in the sampler.

92. Samples were placed in 1-pint airtight jars filled by reaching into the center of the sediment mass. Based on past experience with similar sampling operations, the samples were considered representative of in situ conditions for fine-grained maintenance material.

Bulk samples

93. Bulk sediment samples (approximately 15 gal each) were taken by WES and Norfolk District personnel during April 1980. The purpose of the sampling was to obtain sufficient quantities of material for use in column sedimentation tests. The samples were taken at grab sample locations 1, 8, 16, and 32 (Figure 33). These locations were selected as representative of all material types present. The samples were taken

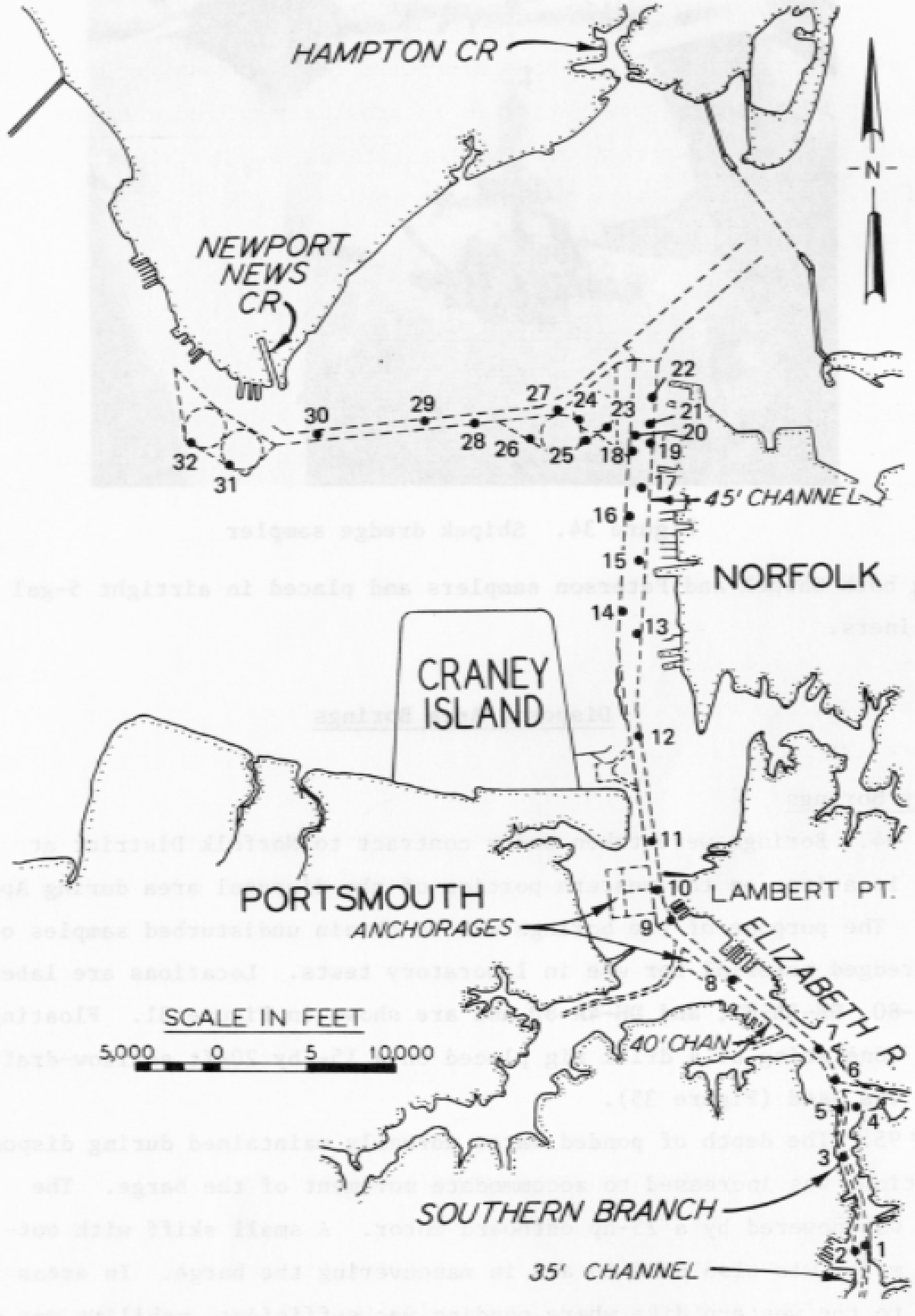


Figure 33. Sediment sample locations

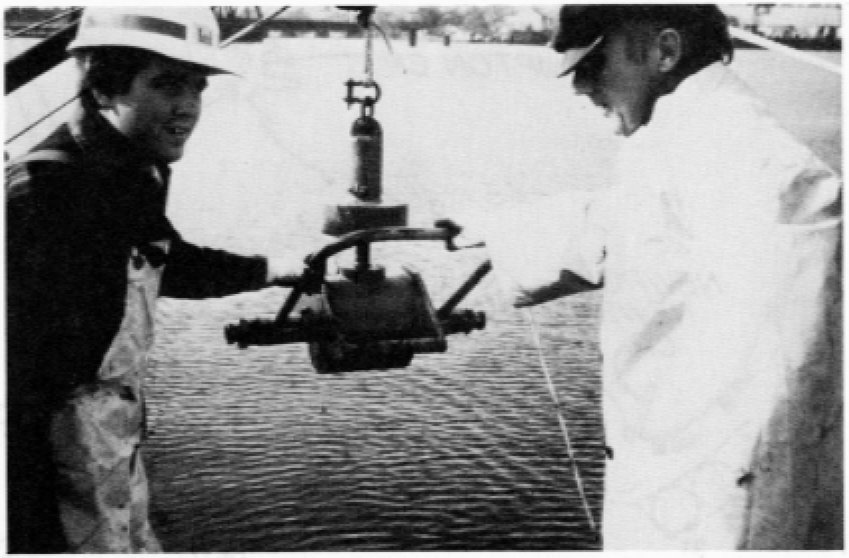


Figure 34. Shipek dredge sampler

using both Shipek and Peterson samplers and placed in airtight 5-gal containers.

Disposal Area Borings

Rotary borings

94. Borings were taken under contract to Norfolk District at three locations on the western portion of the disposal area during April 1980. The purpose of the borings was to obtain undisturbed samples of the dredged material for use in laboratory tests. Locations are labeled DH-2A-80, DH-3A-80, and DH-4A-80 and are shown in Figure 31. Floating plant consisting of a drill rig placed on a 15- by 20-ft shallow-draft barge was used (Figure 35).

95. The depth of ponded water normally maintained during disposal operations was increased to accommodate movement of the barge. The barge was powered by a 25-hp outboard motor. A small skiff with outboard motor was also used to aid in maneuvering the barge. In areas close to the western dike where ponding was sufficient, mobility was not a problem. However, due to the very flat slope of material in the area and practical limitations on depth of ponded water, the barge was unable

Figure 35. Floating plant used for dredged material borings

to maneuver at distances greater than approximately 1500 ft from the western dike. Movement was further limited in a north-south direction by the existing surface topography. A detailed description of boring operations is contained in Pezza and Byrne (1980).

96. A total of 30 undisturbed samples were taken using a 3-in. Shelby Tube sampler. Sampling extended to depths of 24 to 30 ft, penetrating foundation soils 6 to 8 ft. Approximately 2 ft of sample was retained in each push tube. Jar samples were also taken. The tubes were sealed with wax and plastic caps prior to shipment for testing.

97. Piezometers consisting of 1-in.-diam polyvinyl chloride (PVC) pipe were placed in each borehole for later use in monitoring the groundwater table elevation within the dredged material deposit. However, ongoing disposal operations later rendered the piezometers inaccessible. During placement of piezometers, boreholes were bailed and the water level noted 24 hours later. Water levels for boreholes DH-3A-80 and DH-4A-80 were at elevations corresponding to the dredged material surface.

98. Eighteen additional borings were taken during August 1980 in

areas corresponding to traditional points of inflow (Figure 27). Results of these borings are contained in Pezza and Byrne (1980).

Push tube samples

99. A 2-in.-diam Hvorslev piston sampler was used to obtain samples of the existing dredged material in the center portion of the disposal area. The samples were taken at locations DH-5-80, DH-6-80, and DH-7-80 as shown in Figure 31. Samples were taken to depths of 8.5 ft.

Inflow/Effluent Sampling

100. Twenty-one samples of inflow from active disposal operations and effluent from weirs were taken periodically during February, March, and April 1980 to determine suspended solids concentrations. The average values of suspended solids were 168 and 0.035 g/ℓ for inflow and effluent, respectively (>99.9 percent efficiency).

Laboratory Testing

101. Laboratory tests were performed to obtain data regarding physical and engineering characteristics of sediment and dredged material samples. Test procedures and equipment generally conformed with TR DS-78-10 (Palermo, Montgomery, and Poindexter 1978), EM 1110-2-1906 (Office, Chief of Engineers (OCE), 1970), and Standard Methods (American Public Health Association 1971).

Sediment characterization tests

102. Characterization tests were performed on grab and bulk sediment samples by the Norfolk District Laboratory. Tests included USCS classification (WES 1953), water content, Atterberg limits, specific gravity, organic content, and gradation for coarse-grained samples. The results are presented in Table 7.

103. USCS classification. Values of liquid limit (LL) and plasticity index (PI) for sediment samples are shown plotted in Figure 36. The results indicate that all fine-grained samples may be classified as a highly plastic clay (CH). In general, plasticity decreased spatially

Table 7

Sediment Characterization Test Results

Sample Location	Unified Soil Classification	Void Ratio e	In Situ Water Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Organic Content %	Specific Gravity Gs	Percent +0.075 mm
1	(CH) Marine clay	7.26	264	149	46	103	--	2.75	10
2	(CH) Marine clay	9.29	338	174	52	122	--	--	1
3	(SC) Shell fragments and marine clay	--	--	--	--	--	--	--	63
4	(CH) Marine clay	7.07	257	138	40	98	--	2.76	9
5		5.58	203	--	--	--	--	--	21
6		8.19	298	164	46	113	--	--	2
7		6.32	230	131	40	91	--	2.72	1
8		5.72	208	--	--	--	--	--	12
9		6.32	230	--	--	--	--	--	3
10		5.91	215	126	38	88	--	2.77	16
11		5.14	187	--	--	--	--	--	5
12		6.08	221	129	39	90	--	--	5
13		4.81	175	110	31	79	--	2.75	20
14		6.82	248	--	--	--	--	--	1
15		6.76	246	137	42	95	--	2.78	2
16		5.61	204	--	--	--	--	--	3
17		4.40	160	107	32	75	--	--	2
18	(CH) Marine clay	4.70	171	--	--	--	--	--	11
19		5.58	203	126	39	87	6.2	2.77	1
20		4.32	157	--	--	--	--	--	5
21		5.33	194	--	--	--	--	--	3
22		5.23	190	116	36	80	--	2.75	2
23		4.51	164	98	32	66	--	--	8
24		4.18	152	--	--	--	--	--	7
25*		2.34	85	56	24	32	3.3	2.74	30
26*		2.89	105	--	--	--	--	--	19
27*		2.15	78	51	24	27	--	--	25
28*		2.83	103	62	24	38	--	2.72	25
29	(SP) Fine to medium sand	--	--	--	--	--	--	--	98
30	(SP) Fine to medium sand	--	--	--	--	--	--	--	97
31	(CH) Marine clay	3.85	140	89	30	59	--	--	8
32	(CH) Marine clay	4.54	165	107	33	74	5.4	2.78	2
	Average for grab samples	5.64	205	128	38	88	5.8	2.75	15
1-B	(CH) Marine clay	8.19	298	166	49	117	--	--	--
8-B	(CH) Marine clay	4.84	176	113	32	81	--	--	--
16-B	(CH) Marine clay	5.52	201	121	37	84	--	--	--
31-B	(CH) Marine clay	4.07	148	104	30	74	--	--	--

* These grab samples were taken in newly dredged areas at depths below authorized navigation limit and may not be indicative of the nature of fine-grained maintenance material. Results were not considered in determining averages for the grab samples.

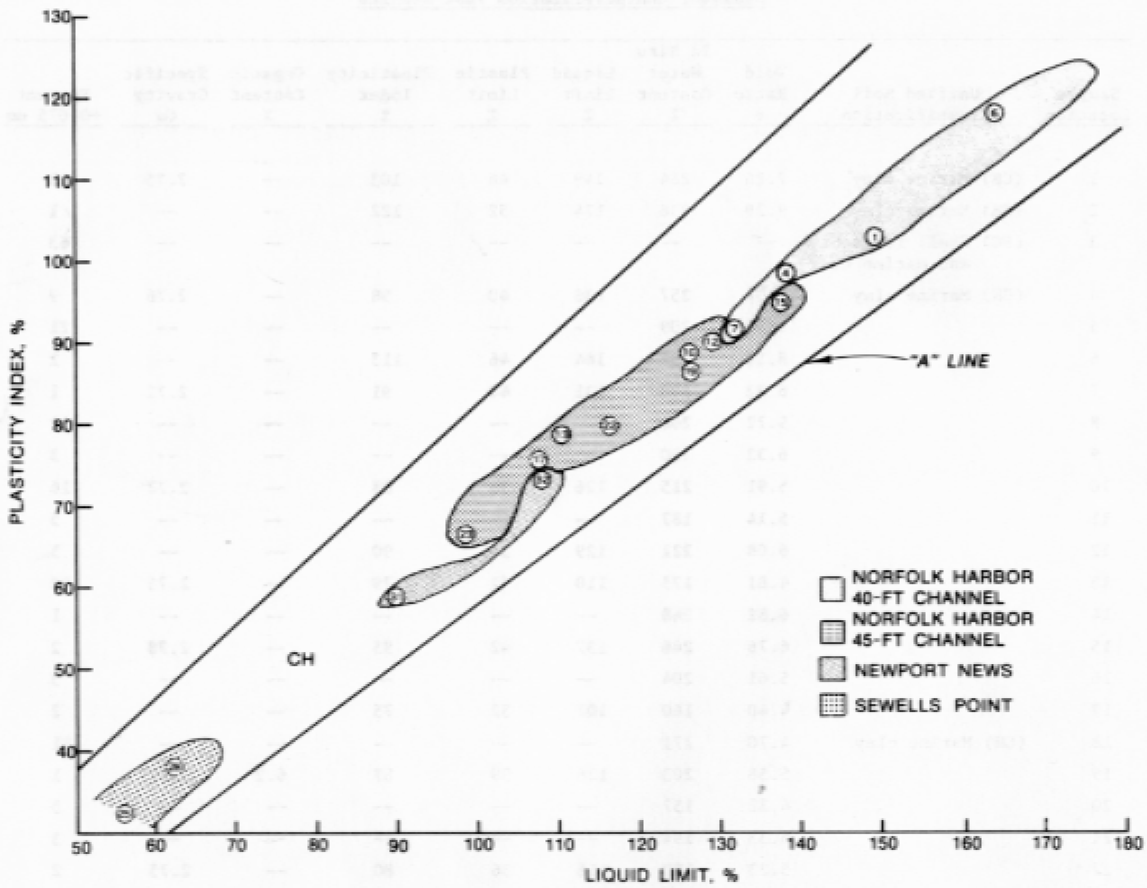


Figure 36. Plot of liquid limit versus plasticity index for sediment samples

south to north in the Elizabeth River reach and east to west in the Newport News reach as seen by the groupings indicated in Figure 36.

104. Water contents. Water contents were obtained for all fine-grained samples of the in situ channel sediment. Results varied from 120 to 338 percent and also followed a trend similar to the plasticity data.

105. Specific gravity. Specific gravity tests were run on 10 sediment samples. The average value of specific gravity was 2.75.

106. Organic content. Organic contents were determined on three sediment samples by WES. The tests were run by measuring change in weight between samples oven dried at 105°C and 440°C. Results indicated that the sediment contained between 3.3 and 6.2 percent organic material.

Dredged material
characterization tests

107. Characterization tests for dredged material samples were performed by the WES Geotechnical Laboratory and under contract to Norfolk District. Tests included USCS classification, water content, and Atterberg limits. The results are presented with the boring logs in Figures 37-42. The engineering properties of in-place dredged material are similar to the sediment samples. Water contents are generally at or above the liquid limit for both the borings near the west dike and those within the central portion of the site. A plot of liquid limit versus plasticity index for the dredged material samples is shown in Figure 43.

Sedimentation tests

108. Sedimentation tests were performed on bulk sediment samples by WES to obtain data for use in the water quality evaluations described in Part IV. It was anticipated that material taken from the saltwater environment within Hampton Roads would exhibit zone settling behavior in column settling tests. Bulk samples 1-B and 16-B were selected for the column settling tests. These sample locations were selected as representative of material exhibiting both the critical and average sedimentation characteristics. A schematic of the testing apparatus is shown in Figure 44.

109. A series of zone settling tests were performed for both samples at initial sediment concentrations ranging from 63 to 200 g/ℓ. An interface formed between the clarified upper layer and more concentrated slurry. The fall of the interface was recorded versus time, allowing a zone settling velocity to be determined for each test. Typical zone settling test results are shown in Figure 45. Individual interface height versus time curves are presented in Appendix C. More detailed discussion of column sedimentation test results is presented in Part IV.

110. A 15-day zone settling test was run on bulk samples 1-B, 16-B, and 31-B to obtain data for volume relationships as described in Part V. The mean solids concentration below the interface was determined from interface heights and mass balance relationships. Plots of

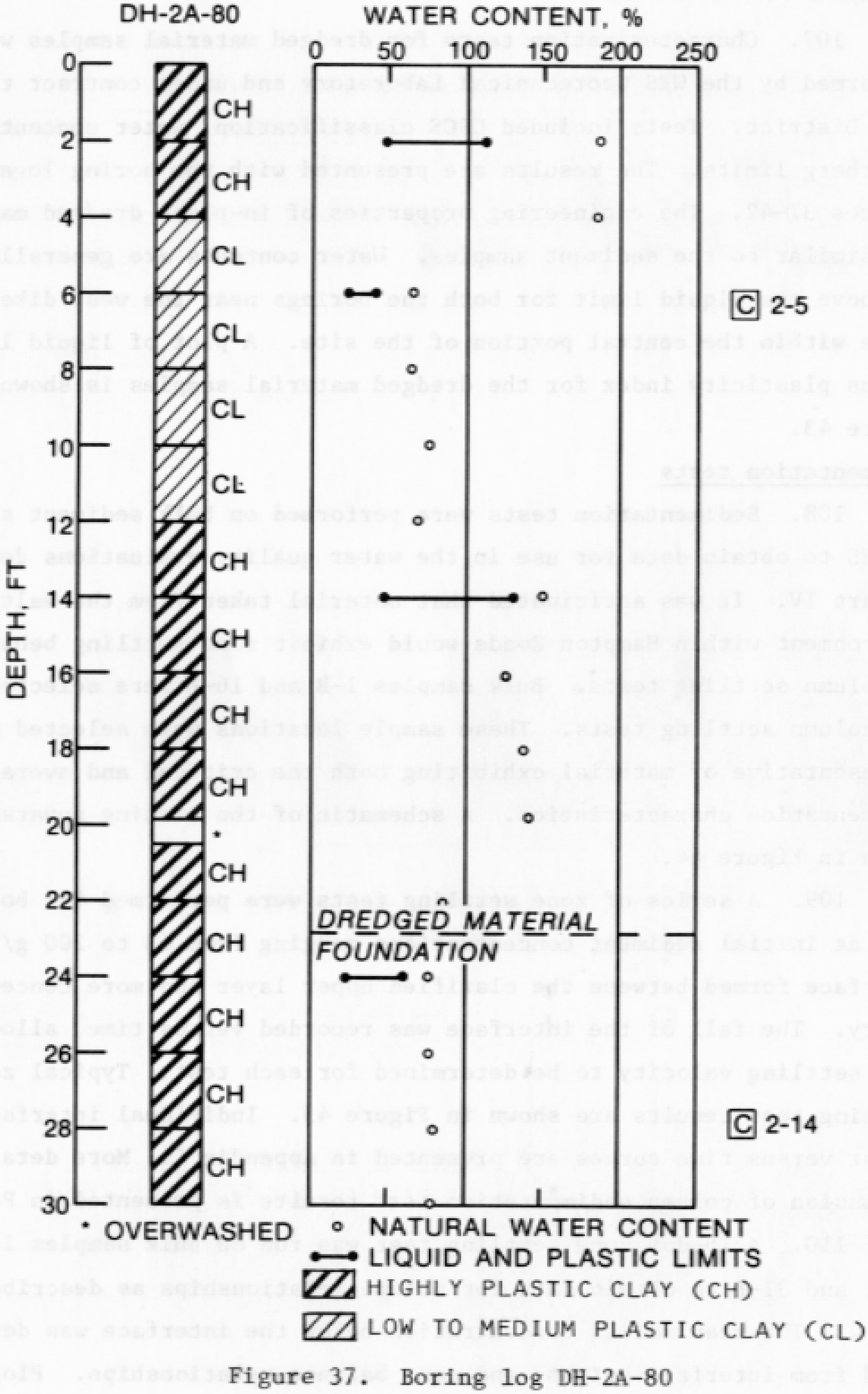


Figure 37. Boring log DH-2A-80

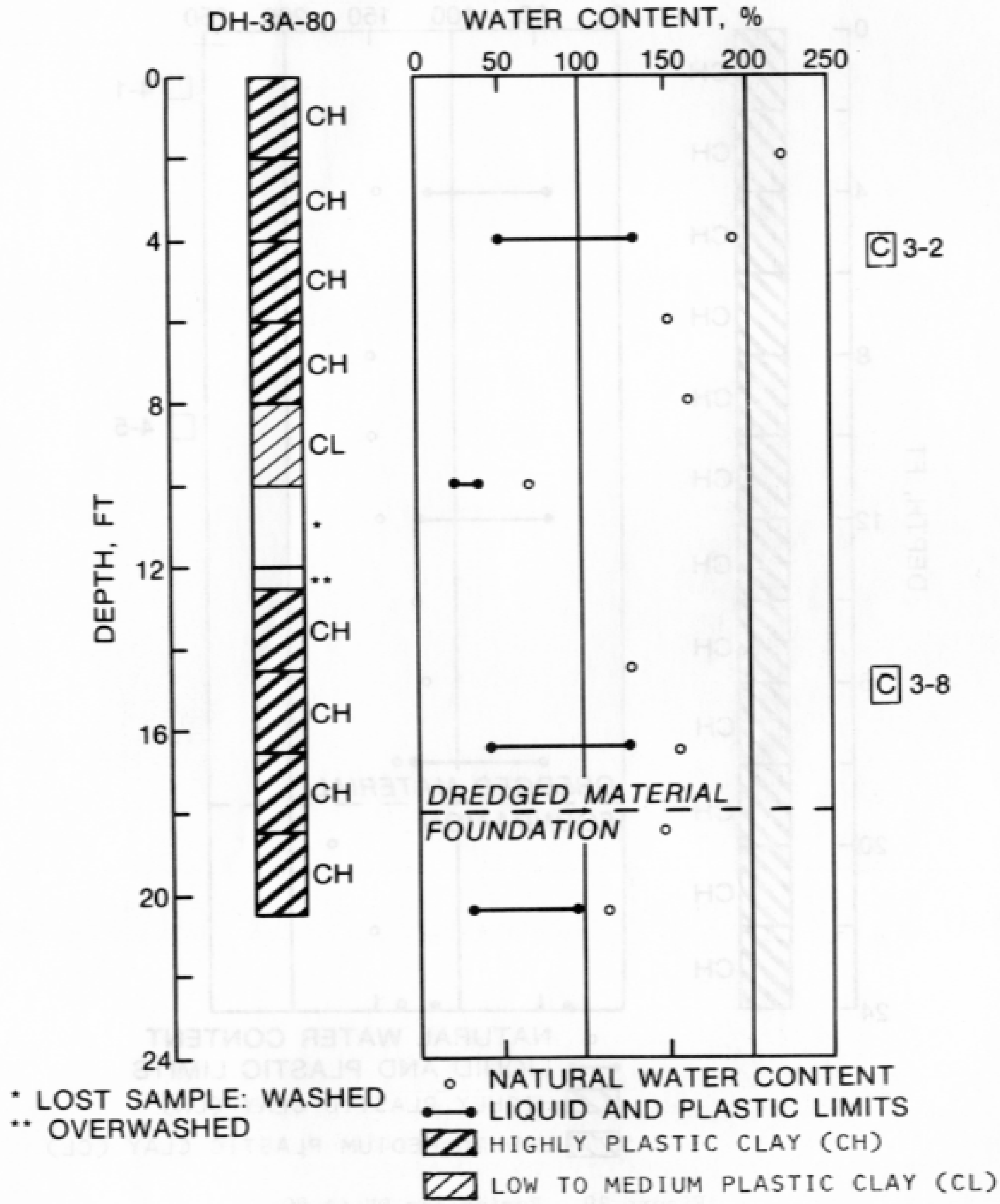


Figure 38. Boring log DH-3A-80

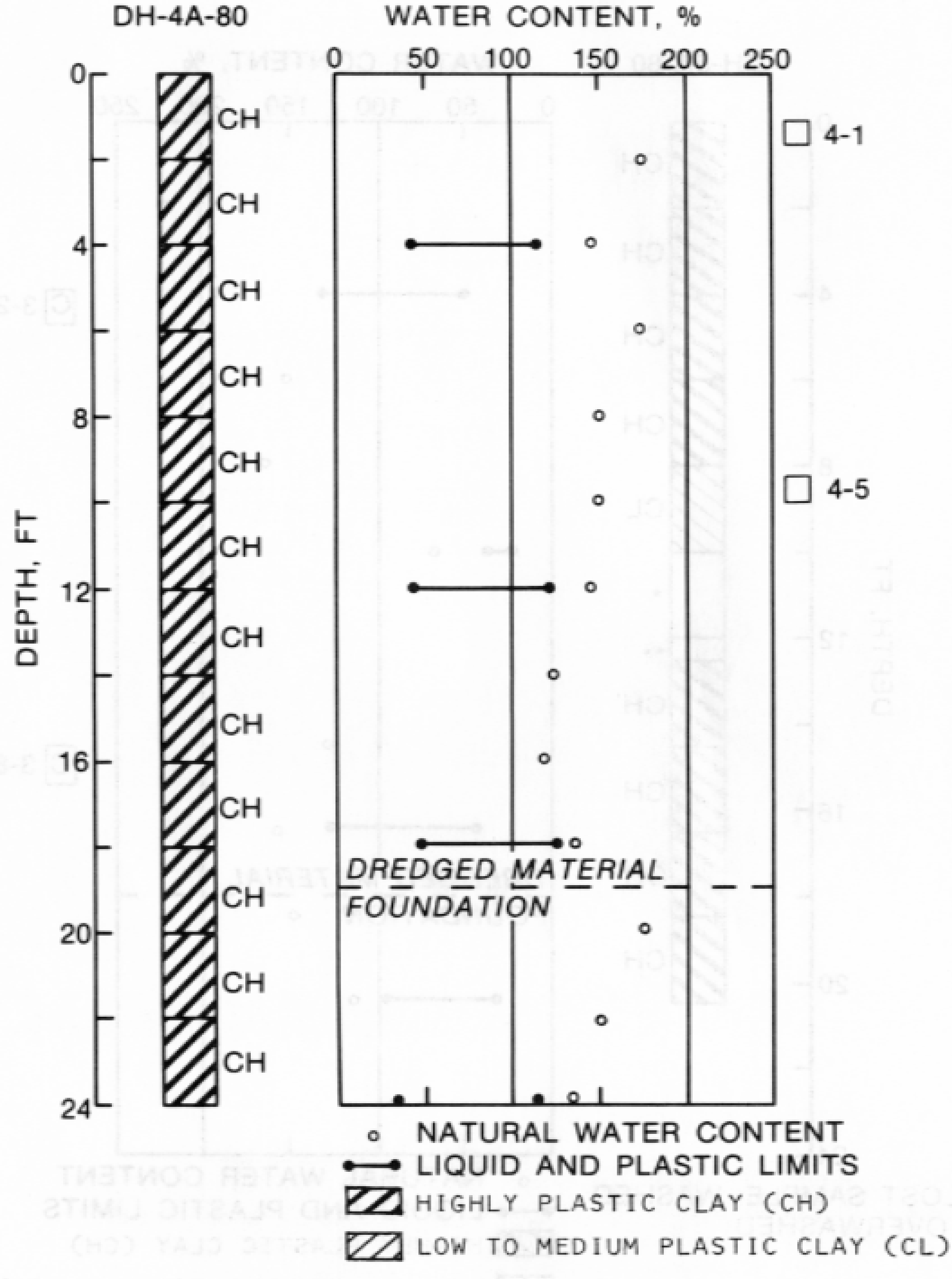


Figure 39. Boring log DH-4A-80

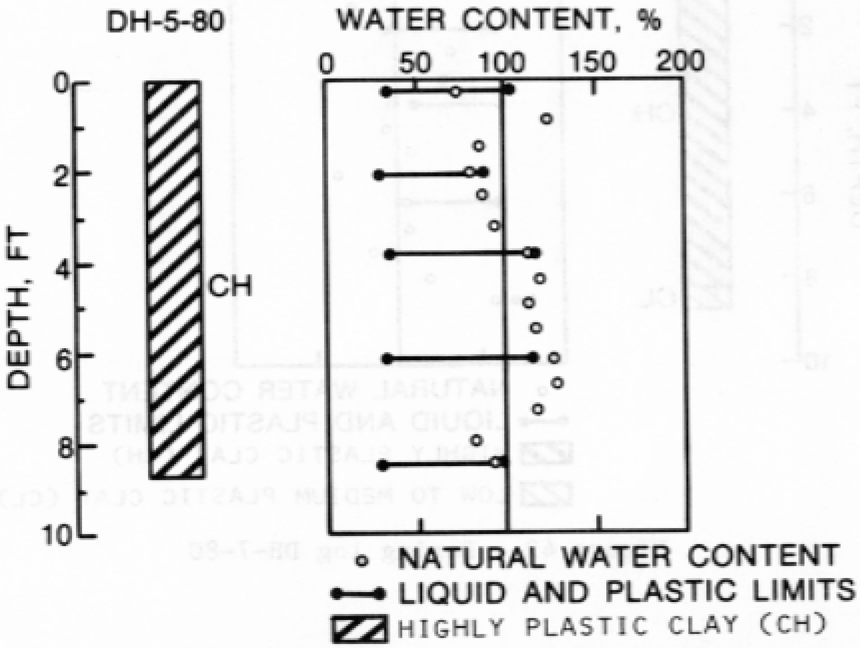


Figure 40. Boring log DH-5-80

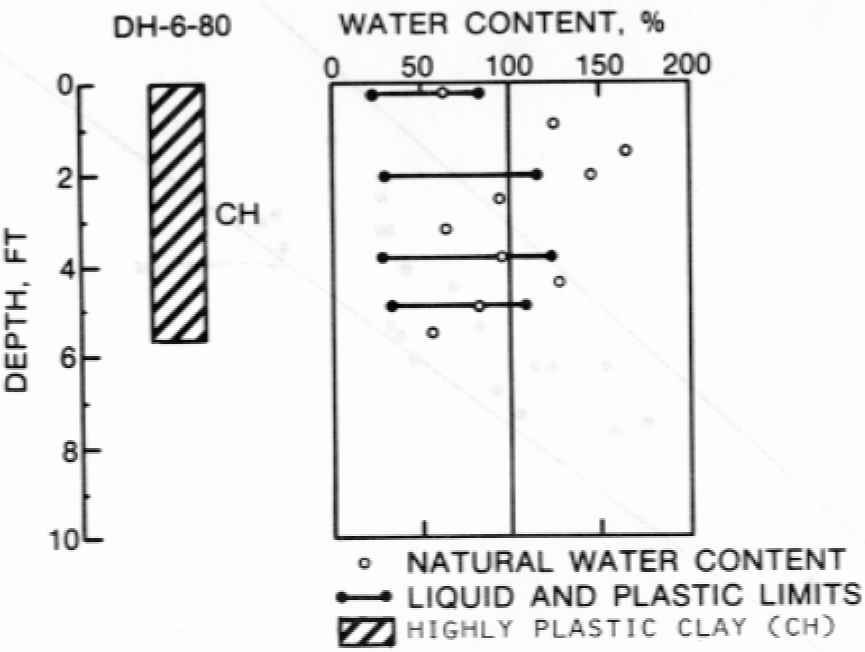


Figure 41. Boring log DH-6-80

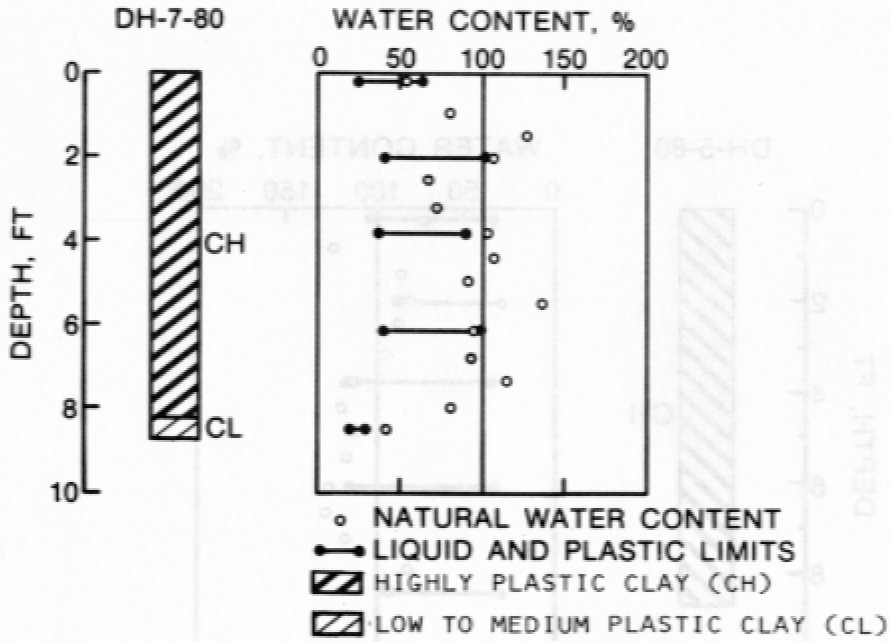


Figure 42. Boring log DH-7-80

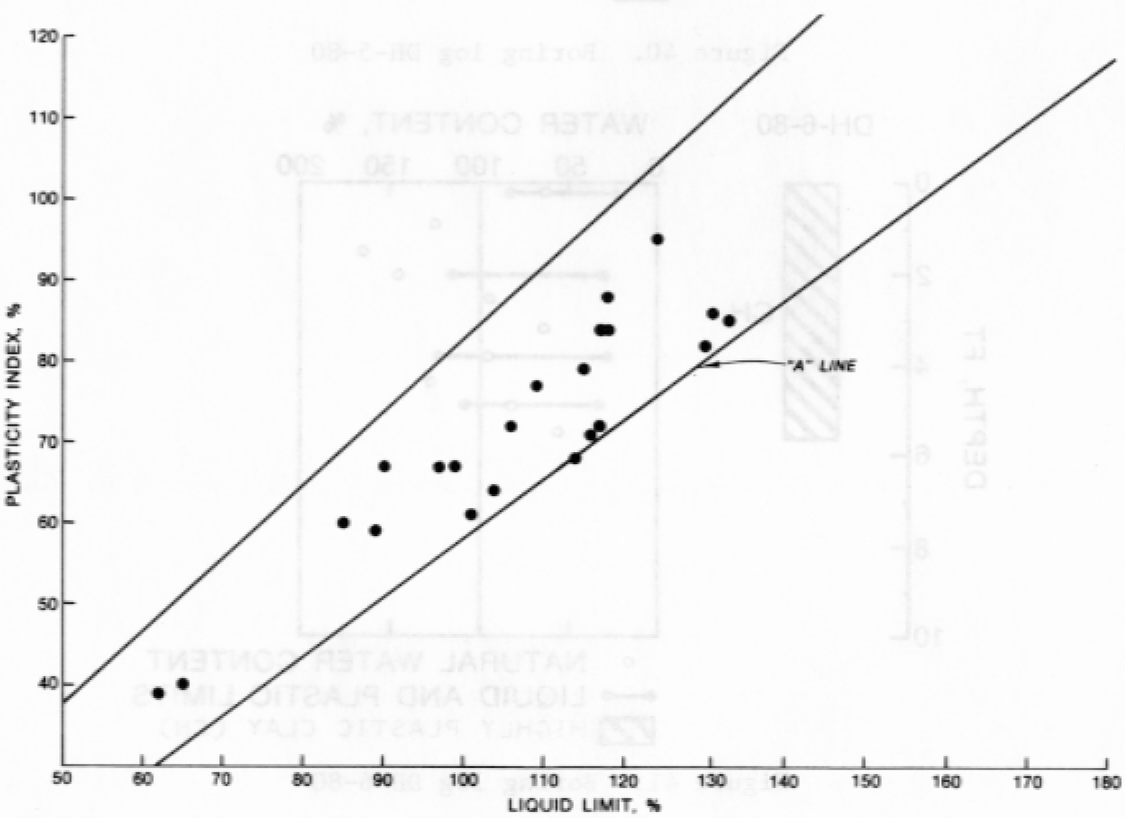


Figure 43. Plot of liquid limit versus plasticity index for dredged material samples

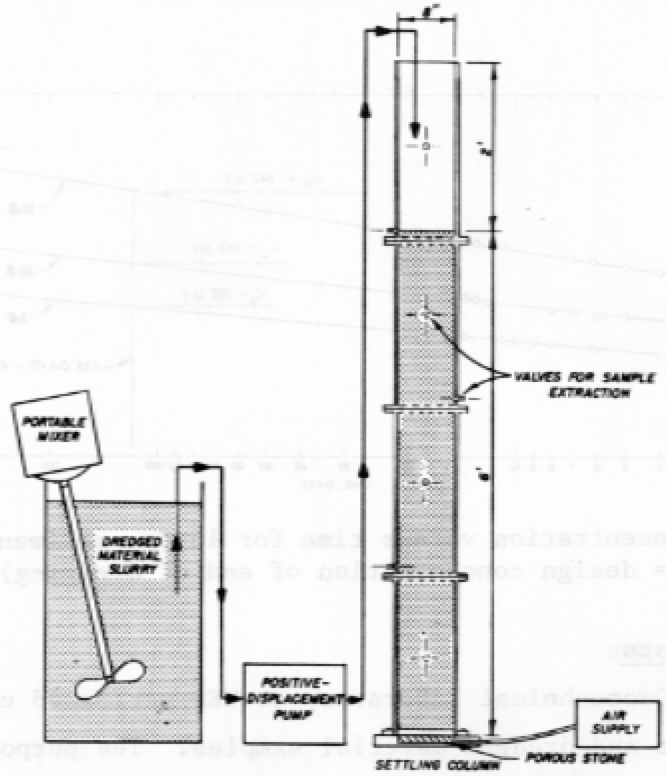


Figure 44. Sedimentation testing apparatus

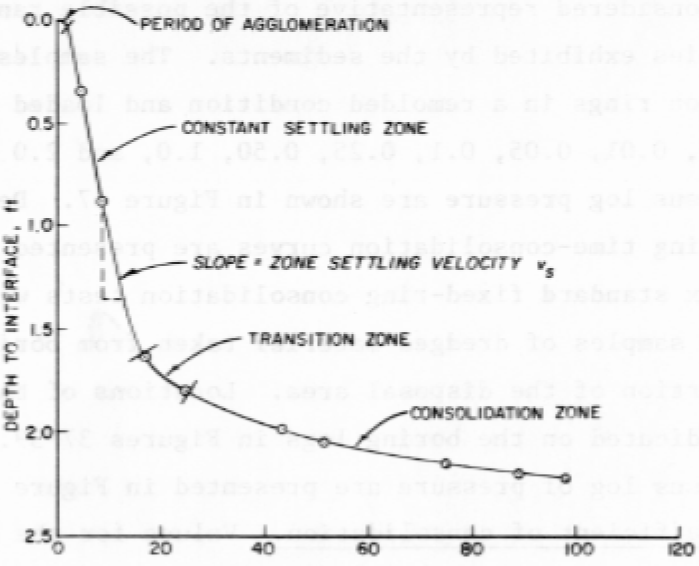


Figure 45. Typical zone settling test results

concentration in g/ℓ versus time for these tests are shown in Figure 46.

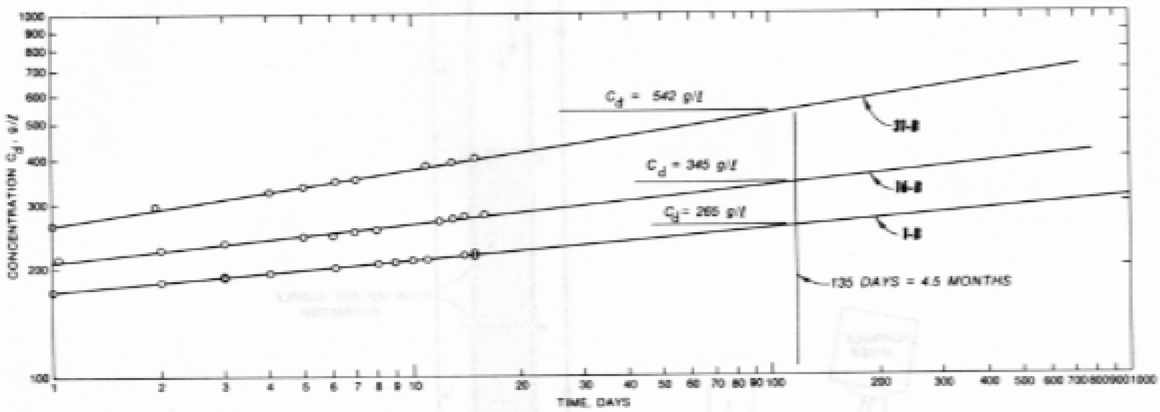


Figure 46. Concentration versus time for 15-day sedimentation tests (C_d = design concentration of end of dredging)

Consolidation tests

111. The Geotechnical Laboratory at WES performed consolidation tests on sediment and dredged material samples. The purpose of consolidation testing was to obtain data for use in evaluation of storage capacity described in Part V. Consolidation tests were performed on two sediment samples taken at locations 1 and 31 (see Figure 33). These samples were considered representative of the possible range of consolidation properties exhibited by the sediments. The samples were placed in consolidation rings in a remolded condition and loaded using increments of 0.013, 0.01, 0.05, 0.1, 0.25, 0.50, 1.0, and 2.0 tsf. Plots of void ratio versus log pressure are shown in Figure 47. Detailed test results including time-consolidation curves are presented in Appendix D.

112. Six standard fixed-ring consolidation tests were performed on undisturbed samples of dredged material taken from borings made in the western portion of the disposal area. Locations of the selected samples are indicated on the boring logs in Figures 37-39. Plots of void ratio versus log of pressure are presented in Figure 48.

113. Coefficient of consolidation. Values for the coefficient of consolidation, c_v , for sediment and dredged material samples were

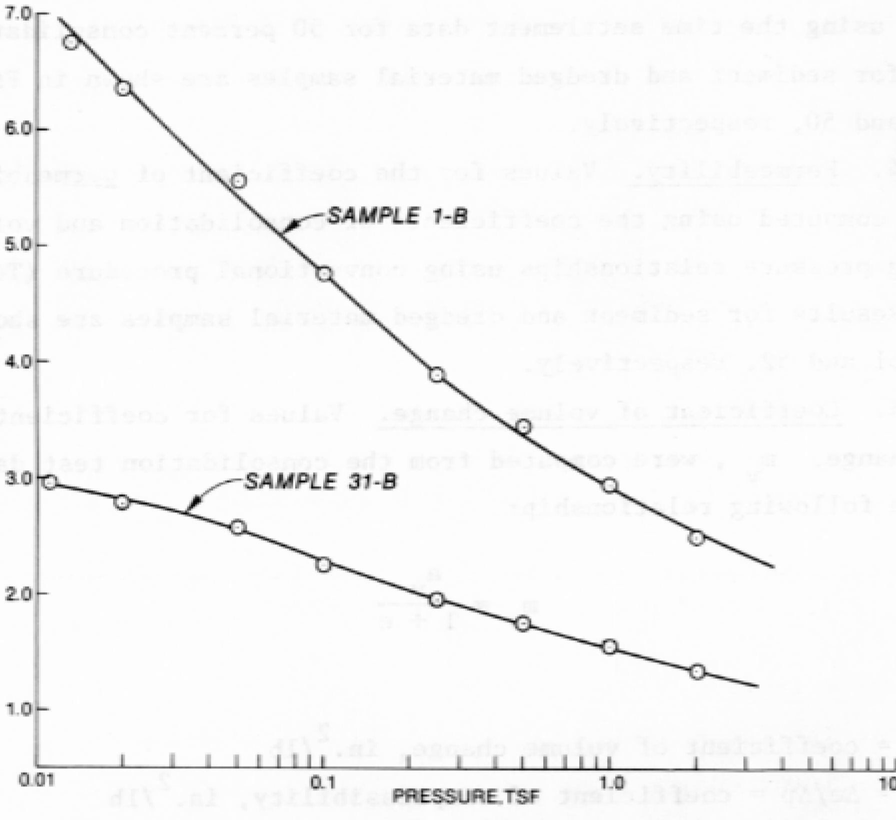


Figure 47. Void ratio versus log pressure for sediment samples

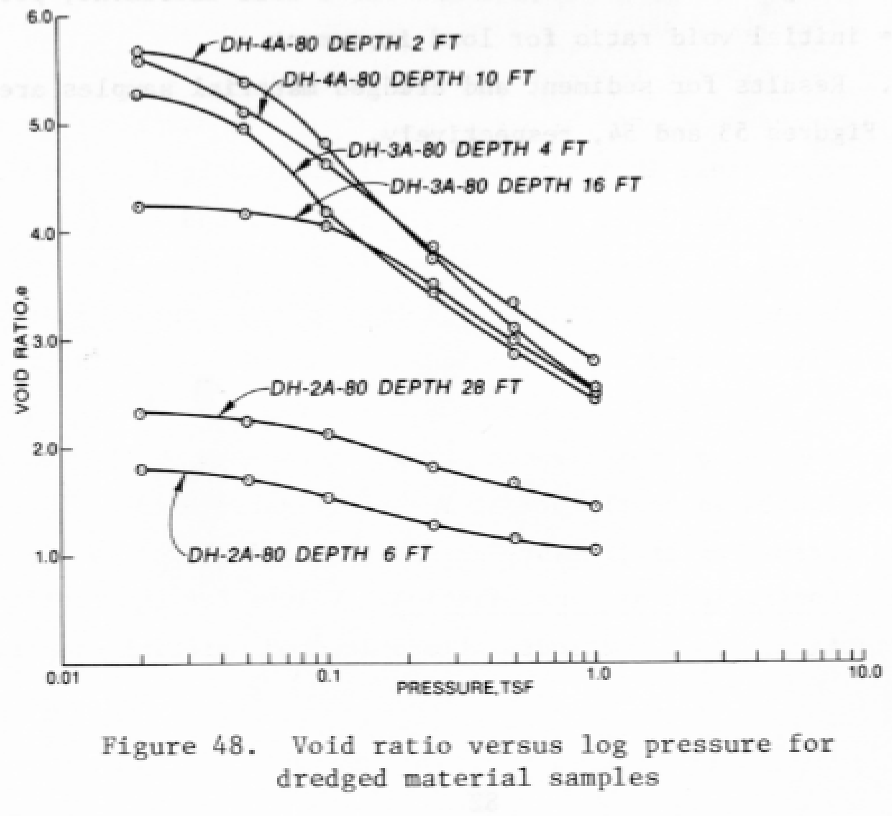


Figure 48. Void ratio versus log pressure for dredged material samples

computed using the time settlement data for 50 percent consolidation. Results for sediment and dredged material samples are shown in Figures 49 and 50, respectively.

114. Permeability. Values for the coefficient of permeability, k , were computed using the coefficients of consolidation and void ratio-log pressure relationships using conventional procedure (Terzaghi 1943). Results for sediment and dredged material samples are shown in Figures 51 and 52, respectively.

115. Coefficient of volume change. Values for coefficient of volume change, m_v , were computed from the consolidation test data using the following relationship:

$$m_v = \frac{a_v}{1 + e} \quad (1)$$

where

m_v = coefficient of volume change, in.^{2}/lb

a_v = $\Delta e/\Delta p$ = coefficient of compressibility, in.^{2}/lb

Δe = change in void ratio over a load increment

Δp = change in effective pressure for a load increment, psi

e = initial void ratio for load increment

116. Results for sediment and dredged material samples are presented in Figures 53 and 54, respectively.

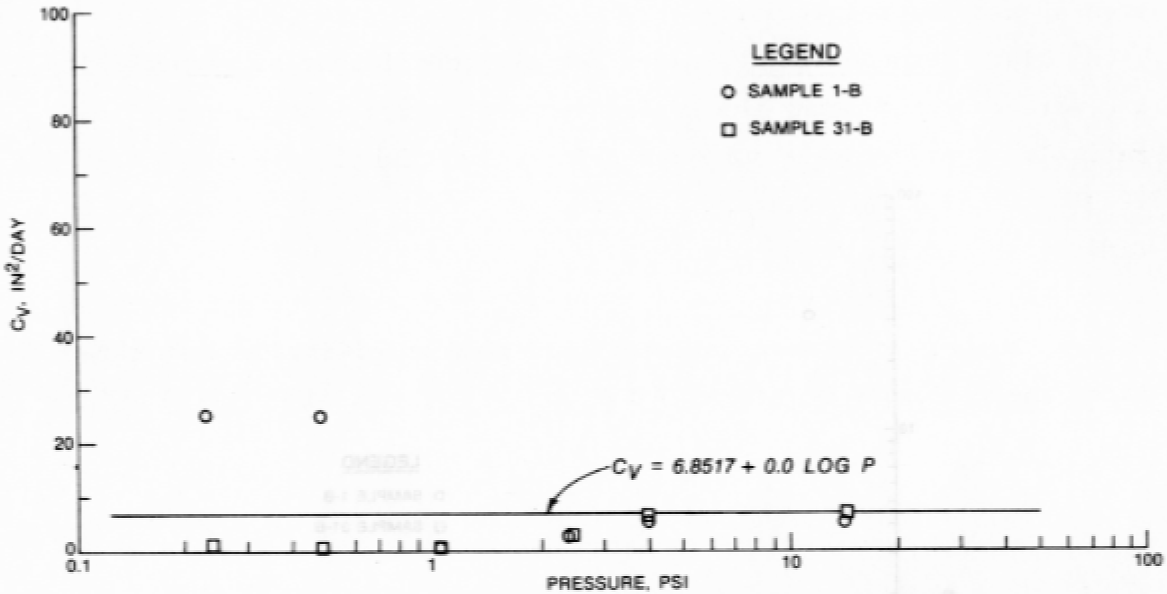


Figure 49. Coefficient of consolidation versus log pressure for sediment samples

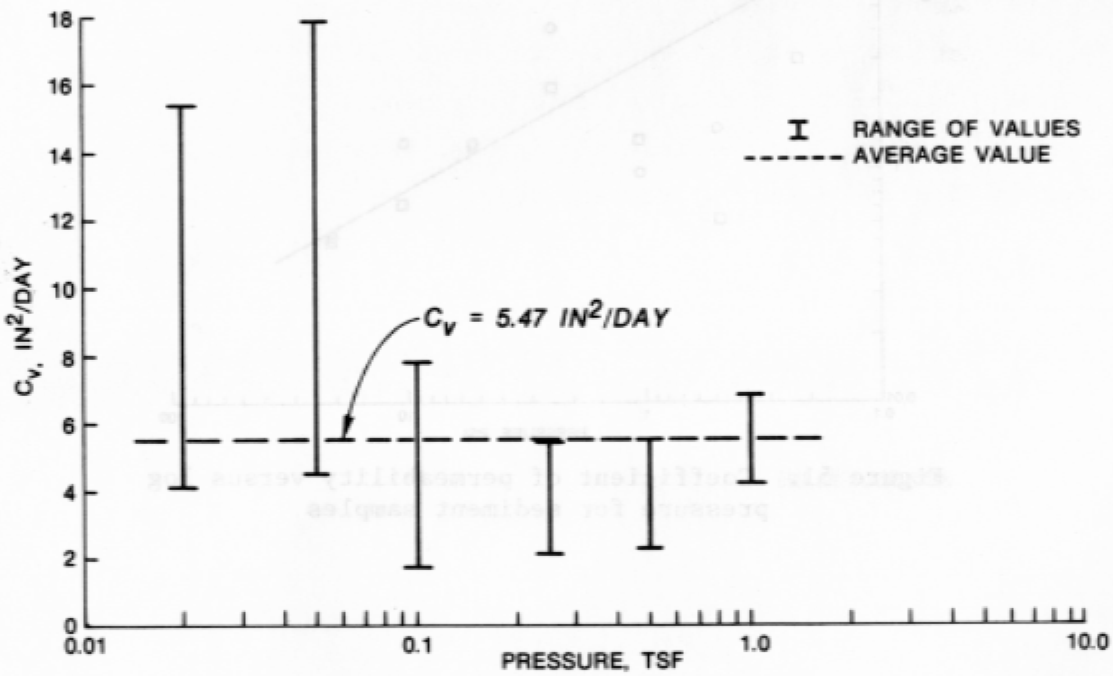


Figure 50. Coefficient of consolidation versus log pressure for dredged material samples

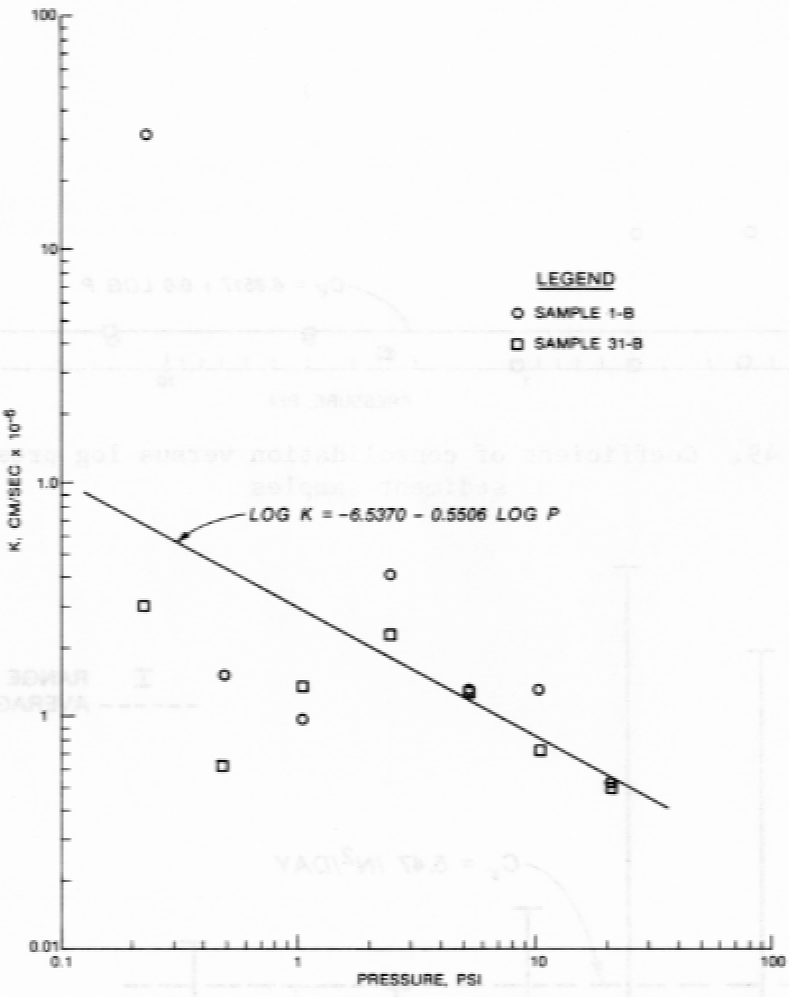


Figure 51. Coefficient of permeability versus log pressure for sediment samples

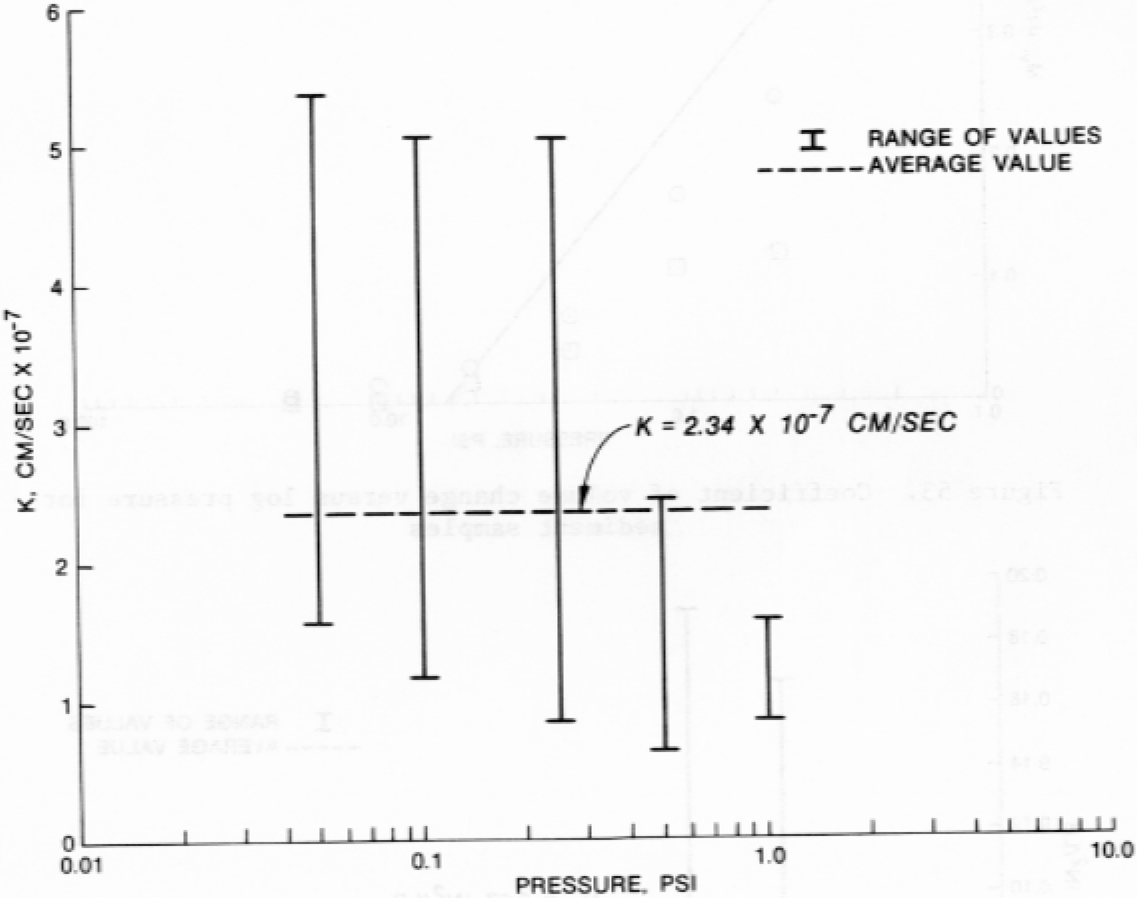


Figure 52. Coefficient of permeability versus log pressure for dredged material samples

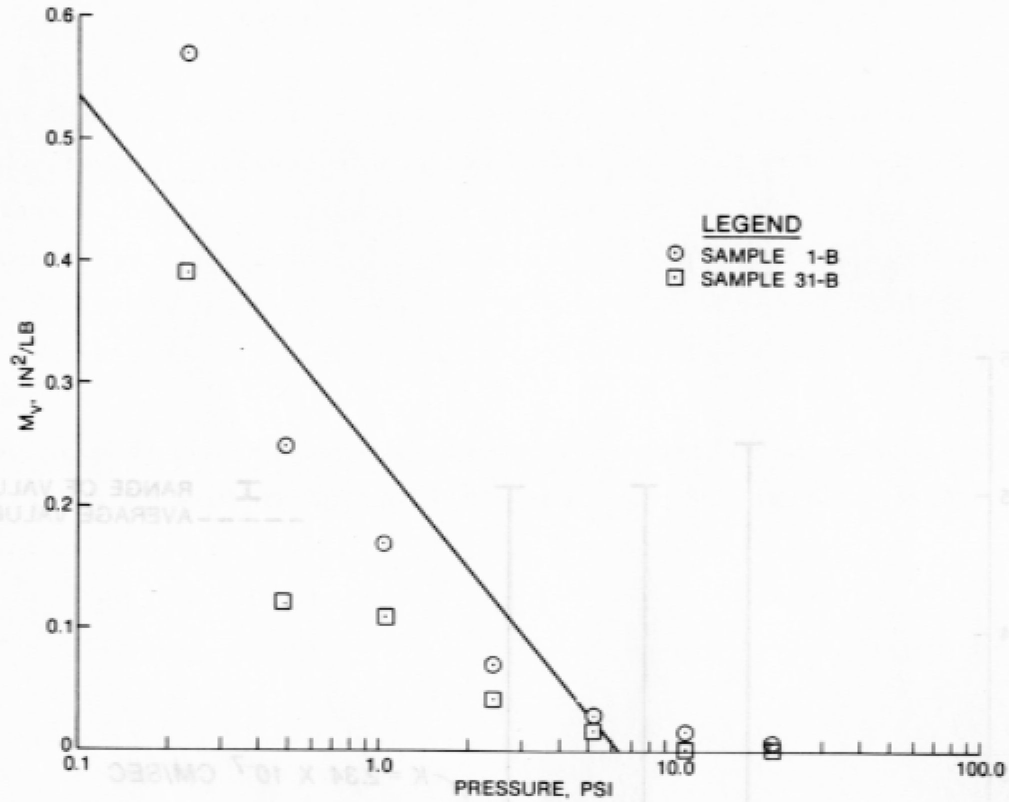


Figure 53. Coefficient of volume change versus log pressure for sediment samples

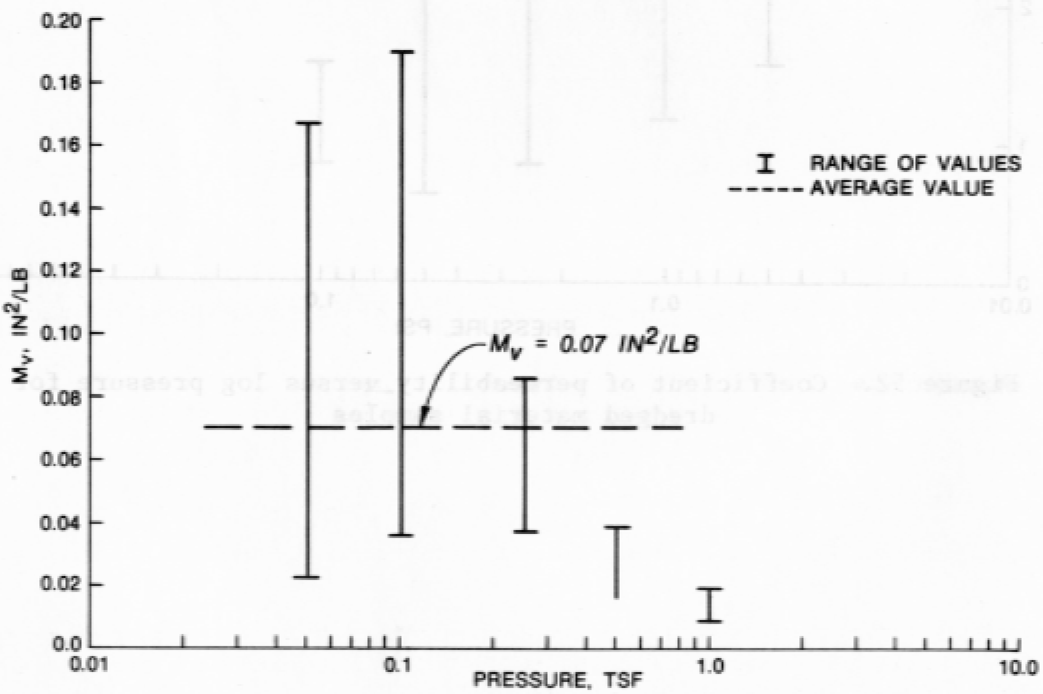


Figure 54. Coefficient of volume change versus log pressure for dredged material samples

PART IV: WATER QUALITY EVALUATION

117. Historically, the water quality* of effluent from the Craney Island disposal area has been within acceptable levels. However, completion of interior dikes for purposes of managing the disposal area would necessarily reduce the area available for dredged material sedimentation during any discrete disposal activity. Without modification of operational procedures, effluent water quality might be adversely affected.

118. This part of the report describes analysis of various subcontainment configurations from the standpoint of effluent water quality. Hydraulic efficiency, sedimentation performance, and weir performance of the various configurations are evaluated; and constraints regarding subcontainment configuration and operation are described. The procedures used in the water quality evaluation are described in detail in Montgomery (1978) and Palermo, Montgomery, and Poindexter (1978).

Analysis of Laboratory Data

119. Laboratory tests were performed as described in Part III to determine the settling properties of sediment to be dredged. Samples taken from Stations 1-B and 16-B exhibited zone settling, consistent with a saltwater environment. A series of zone settling tests, each with a different initial solids concentration, were run for each station, and resultant plots of time versus interface height are presented in Appendix C. The zone settling velocity is equal to the slope of the constant settling segment of the time versus interface height curve.

120. Design curves were generated from the relationship between zone settling velocity and initial solids concentration and are presented in Figures 55 and 56. These plots were used to develop solids loading versus initial solids concentration curves (Figures 57 and 58).

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* Water quality as discussed in this report refers only to concentrations of suspended solids within the effluent.

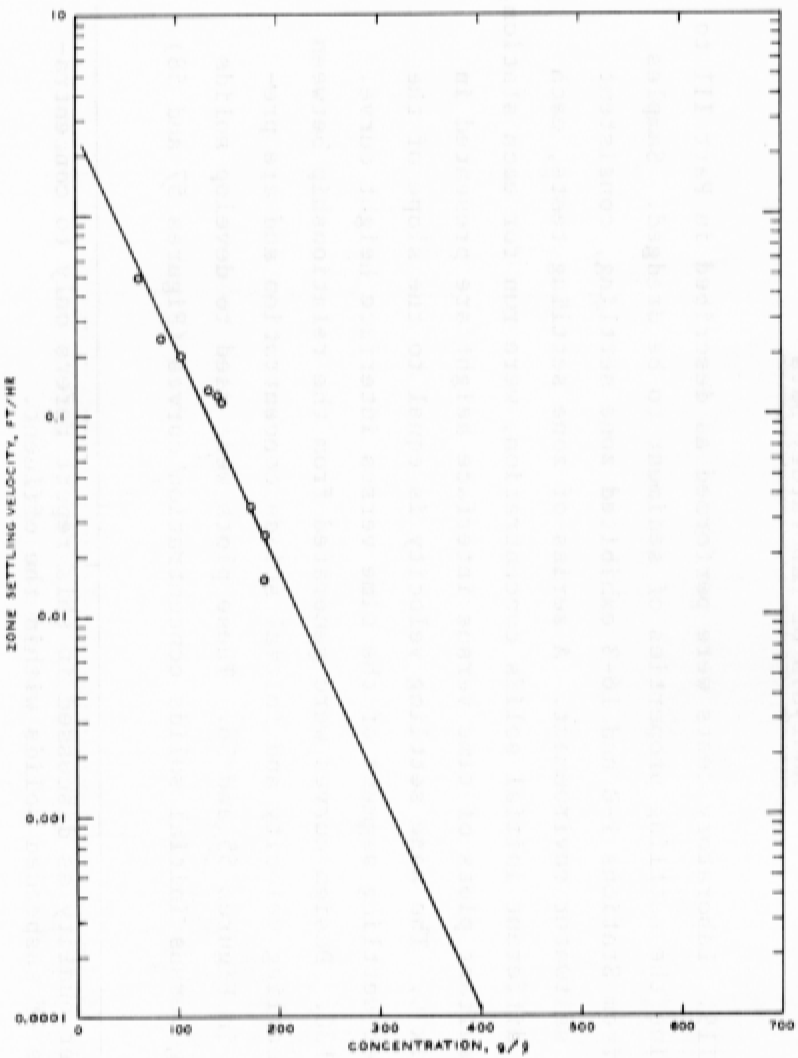


Figure 55. Zone settling velocity versus concentration, sample 1-B

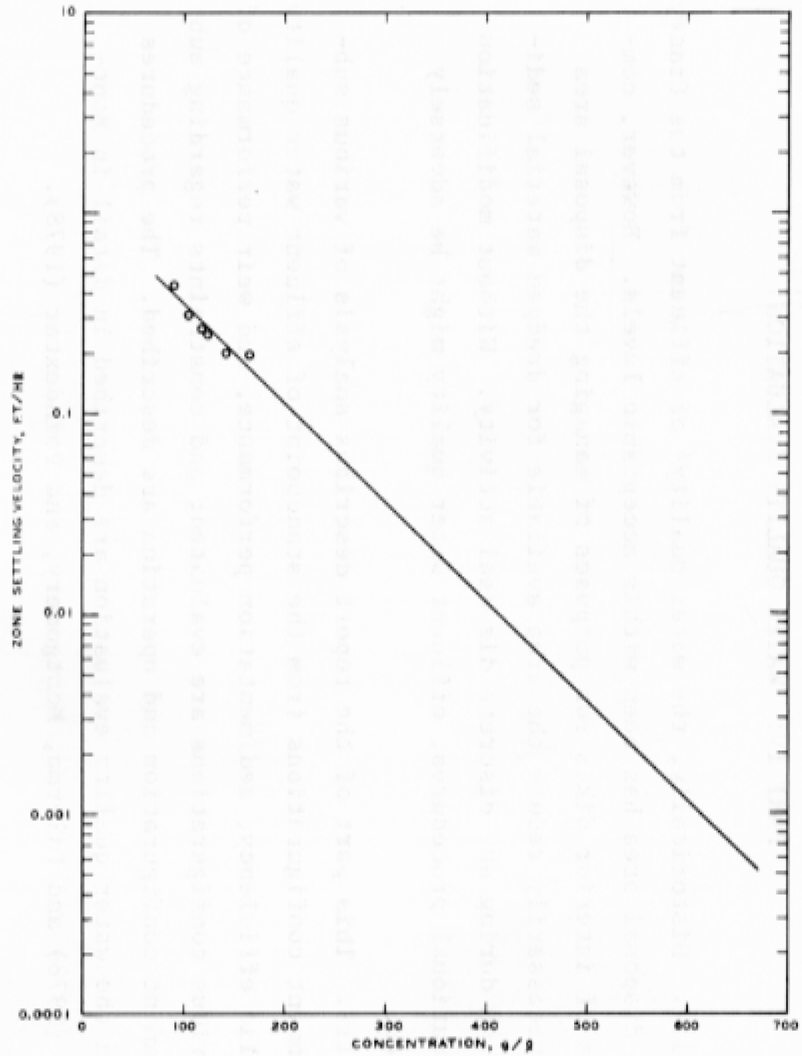


Figure 56. Zone settling velocity versus concentration, sample 16-B

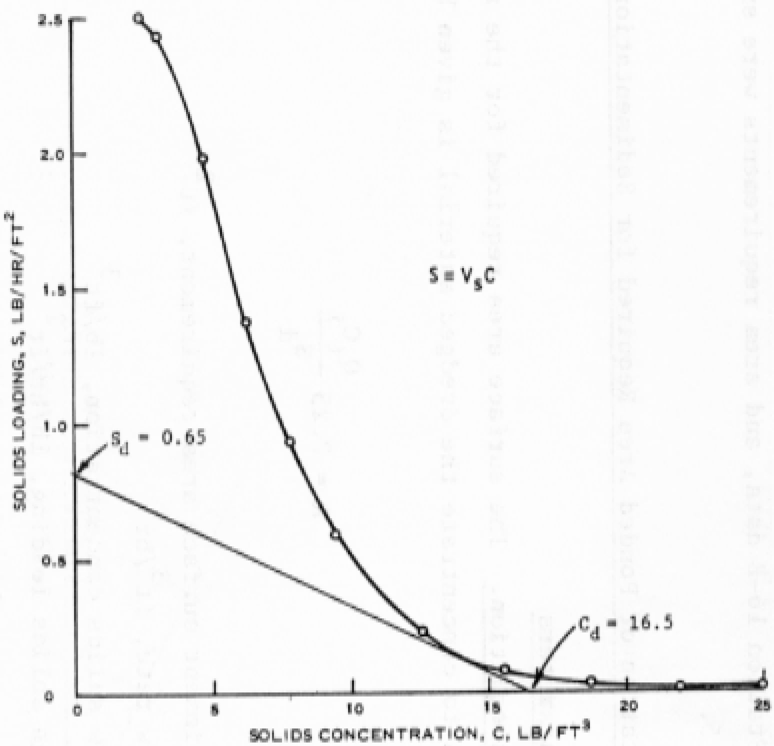


Figure 57. Solids loading curve, sample 1-B

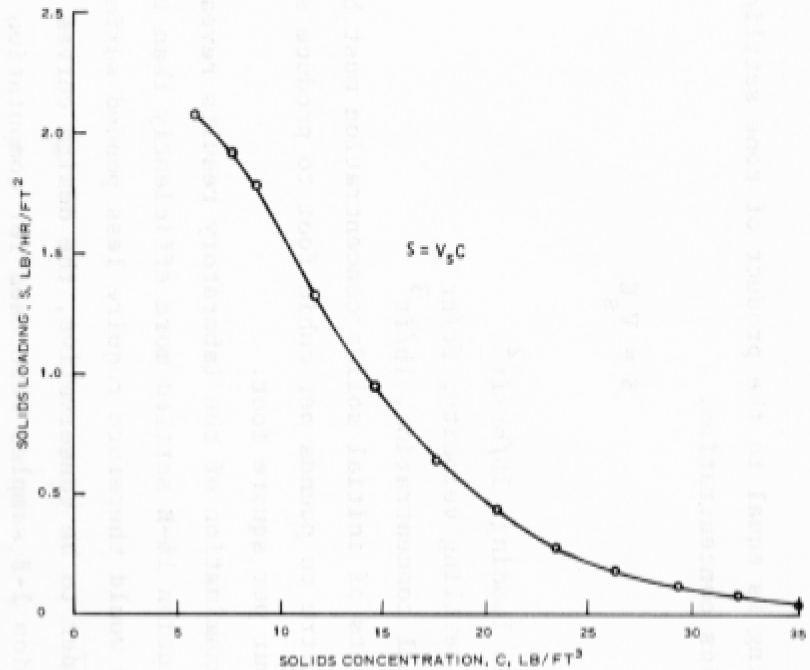


Figure 58. Solids loading curve, sample 16-B

The solids loading is equal to the product of zone settling velocity and initial solids concentration.

$$S = V_s C \tag{2}$$

where

S = solids loading, $lb/hr/ft^2$

V_s = zone settling velocity, ft/hr

C = initial concentration, lb/ft^3

Note that the units of initial solids concentration must be converted from grams per litre to pounds per cubic foot to produce solids loading in pounds per hour per square foot.

121. An examination of the laboratory results revealed that the material from Station 16-B settled more efficiently than that from Station 1-B, and would therefore require less ponded surface area for settling. In order to be conservative, the design curves produced from analysis of Station 1-B samples were used for computation of required ponded areas. For purposes of comparison, area requirements were also computed using Station 16-B data, and area requirements were smaller by factors of 3 to 5.

Computation of Ponded Area Required for Sedimentation

Sedimentation parameters

122. Area equation. The surface area required for the zone settling process to concentrate the dredged material is given by the equation

$$A = 2.25 \frac{Q_i C_i}{S_d} \tag{3}$$

where

A = containment surface area requirement, ft^2

Q_i = inflow rate, ft^3/hr

C_i = inflow solids concentration, lb/ft^3

S_d = design solids loading, $lb/hr/ft^2$

The correction factor of 2.25 is required to compensate for containment area inefficiencies. Methods used for selection of design values for these parameters are described in the following paragraphs.

123. Inflow rate. Inflow rate and required ponded area are directly proportional. Therefore, high inflows require larger surface areas. The value of inflow rate used for design was determined by examining dredging contract records for Craney Island for the years 1955-1980. A large portion of contract records included dredge pipe diameters. Flow rates were computed by summing pipe cross-sectional areas for concurrent contracts and multiplying the sum of areas by discharge velocity. A range of inflows was thus computed. The following tabulation is a summary of some of these computations:

Case	Pipe Diameters for Concurrent Contracts, in. d_1	d_2	d_4	d_5	Estimated Inflow cfs*
1	16	--	--	--	16.0
2	30	--	--	--	60.0
3	22	30	--	--	91.0
4	22	18	18	18	95.0
5	22	30	18	--	112.0
6	16	18	22	30	128.0

* Based on an average discharge velocity of 12 fps.

124. An inflow rate of 95 cfs was judged representative of an "average" design condition, a flow which could occur over an extended time period. An inflow rate of 130 cfs was judged representative of a "critical" design condition, a flow which could possibly occur over short time periods.

125. Design concentration. The design solids loading, S_d, may be determined graphically from the solids loading curve (Figures 57 and 58) if the design concentration, C_d, is known. The design concentration is defined as the average concentration of the dredged material

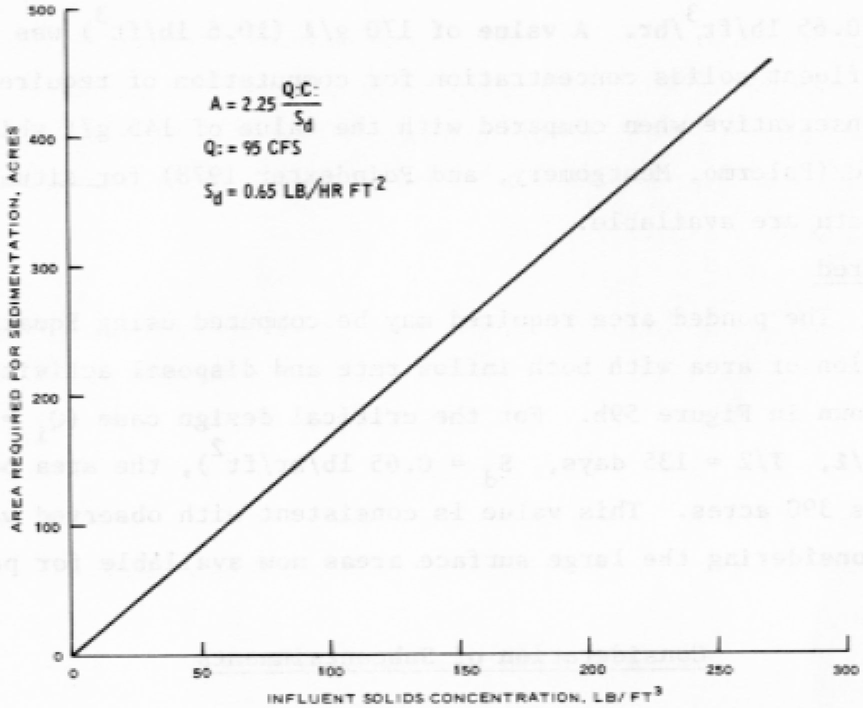
in the containment area at the end of the disposal activity. The design concentration may be read from the plot of solids concentration versus time generated from 15-day settling tests. The time corresponding to the design concentration is one-half the lifetime of the disposal activity. This assumes a fairly uniform rate of dredging. Typical disposal activity lifetimes for Craney Island were approximated by dredging contract lifetimes. Contract lifetimes have ranged from about 17 months to less than 1 month during the period 1955-1980. The longest contract began late in 1970 and ran until early 1972. When coupled with the assumption of a high inflow rate, a disposal activity lifetime of 9 months was judged to be sufficiently conservative. A design concentration of 265 g/ℓ (16.5 lb/ft^3) was read from the plot of the 15-day test for sample 1-B (Figure 46). Time was taken to be one-half of the disposal activity lifetime or 135 days.

126. Design solids loading rate. The design solids loading rate may be determined graphically from the solids loading curve (Figure 57) by constructing a line tangent to the curve from the design solids concentration, C_d. The point of intersection with the vertical axis is the proper design solids loading. Using the solids loading curve for Station 1-B data (Figure 57) and $C_d = 16.5\ lb/ft^3$, S_d was found to be 0.65 $lb/hr/ft^2$.

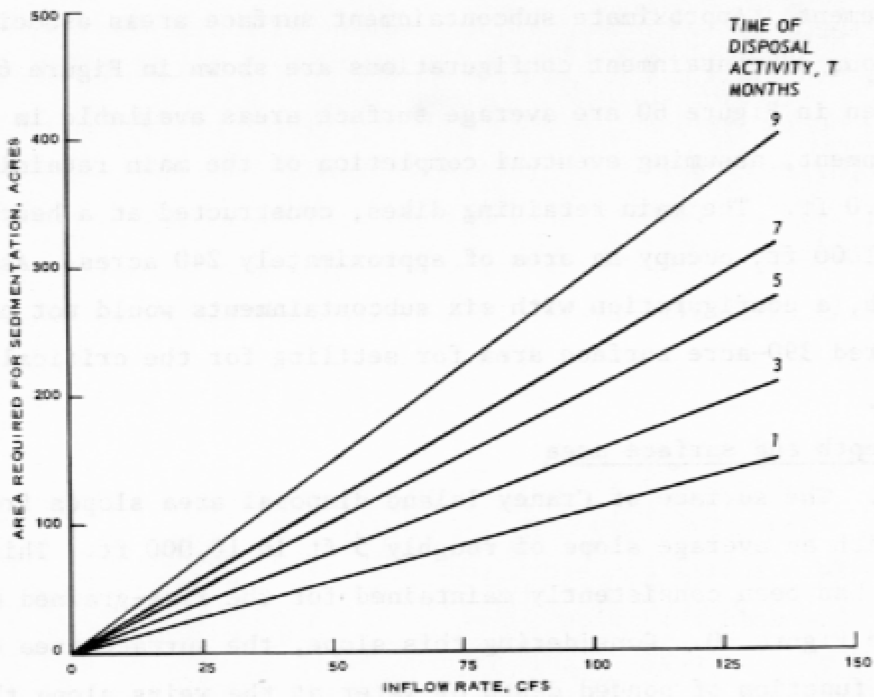
127. Inflow solids concentration. Solids concentrations of twelve samples of dredged material discharging into Craney Island were determined as described in Part III. Statistics for these twelve samples are as follows:

	g/ℓ	lb/ft^3
Maximum solids concentration	335	20.8
Minimum solids concentration	6.5	0.4
Mean solids concentration	168	10.4
Standard deviation	106	6.3

Surface area required for settling is directly proportional to inflow solids concentration (Equation 3). Figure 59a shows ponded area required as a function of influent solids concentration with $Q_i = 95$ cfs



a. Influent solids concentration



b. Inflow rate

Figure 59. Area required for sedimentation as a function of influent solids concentration and inflow rate

and $S_d = 0.65 \ lb/ft^3/hr$. A value of 170 g/ℓ (10.6 lb/ft^3) was chosen for the influent solids concentration for computation of required areas. This is conservative when compared with the value of 145 g/ℓ which is recommended (Palermo, Montgomery, and Poindexter 1978) for situations where no data are available.

Area required

128. The ponded area required may be computed using Equation 3. The variation of area with both inflow rate and disposal activity lifetime is shown in Figure 59b. For the critical design case (Q_i = 130 cfs, C_i = 170 g/ℓ, T/2 = 135 days, $S_d = 0.65 \ lb/hr/ft^2$), the area ponded required is 390 acres. This value is consistent with observed water quality, considering the large surface areas now available for ponding.

Consideration of Subcontainments

129. The Craney Island disposal area could be subdivided a number of ways in order to increase the storage capacity and opportunity for management. Approximate subcontainment surface areas associated with various subcontainment configurations are shown in Figure 60. The areas given in Figure 60 are average surface areas available in each subcontainment, assuming eventual completion of the main retaining dikes to el +30.0 ft. The main retaining dikes, constructed at a bench distance of 1000 ft, occupy an area of approximately 240 acres. As seen in Figure 59b, a configuration with six subcontainments would not provide the required 390-acre surface area for settling for the critical design condition.

Ponding depth and surface area

130. The surface of Craney Island disposal area slopes from east to west with an average slope of roughly 5 ft in 10,000 ft. This average slope has been consistently maintained for the fine-grained material as seen in Figure 30. Considering this slope, the surface area of the pond is a function of ponded depth of water at the weirs along the west dike, much like a reservoir. With completion of the main retaining dikes to an elevation of +30.0 ft, the mean east-to-west dimension of

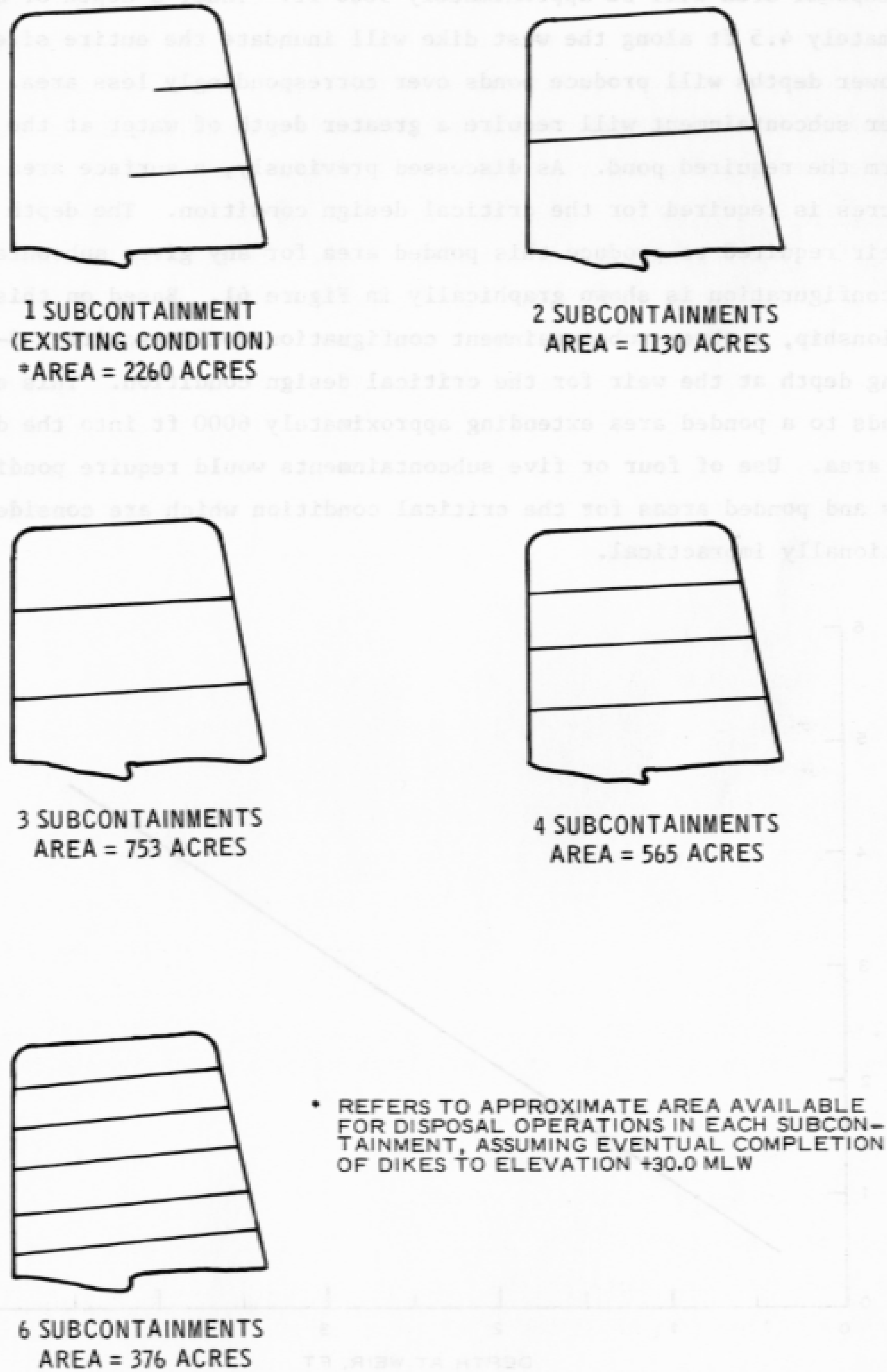


Figure 60. Subcontainment configurations

the disposal area will be approximately 9000 ft. Thus, a depth of approximately 4.5 ft along the west dike will inundate the entire site. Shallower depths will produce ponds over correspondingly less area. A smaller subcontainment will require a greater depth of water at the weir to form the required pond. As discussed previously, a surface area of 390 acres is required for the critical design condition. The depth at the weir required to produce this ponded area for any given subcontainment configuration is shown graphically in Figure 61. Based on this relationship, a three-subcontainment configuation would require a 3-ft ponding depth at the weir for the critical design condition. This corresponds to a ponded area extending approximately 6000 ft into the disposal area. Use of four or five subcontainments would require ponding depths and ponded areas for the critical condition which are considered operationally impractical.

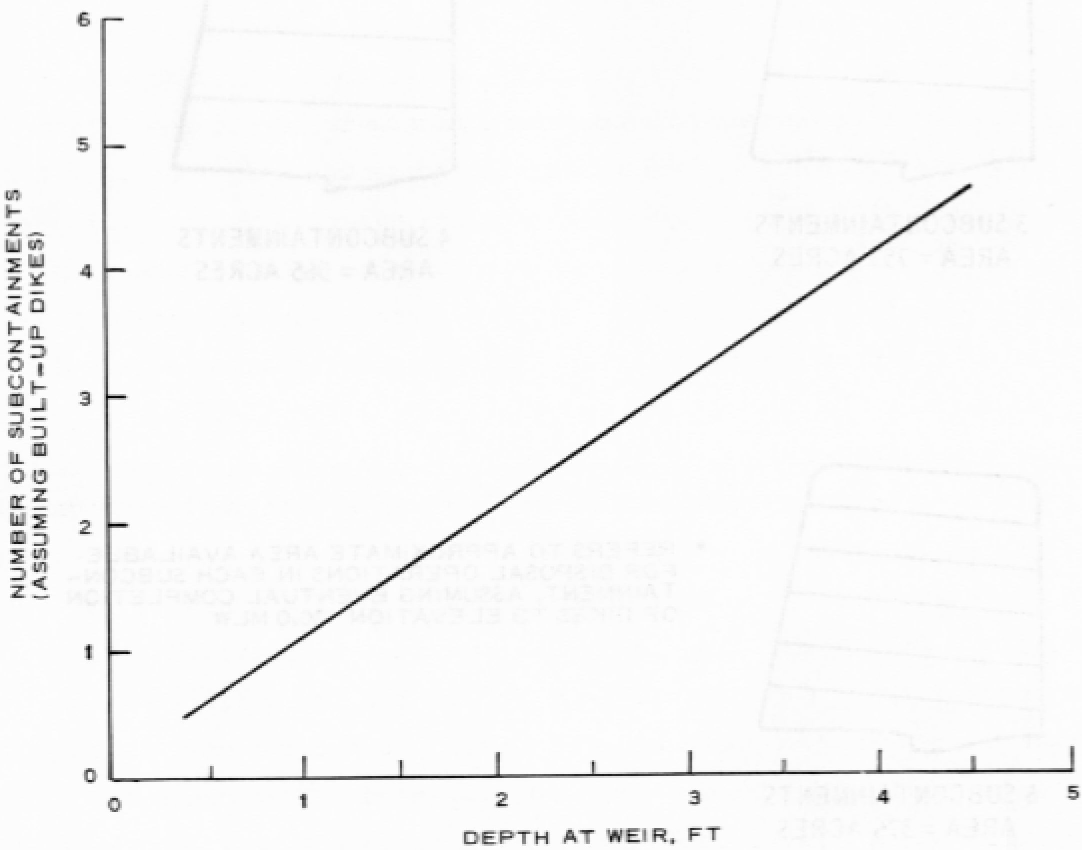


Figure 61. Ponded depth at weir required for various subcontainment configurations

131. From the standpoint of effluent water quality, the Craney Island disposal area could be operated using a maximum of three subcontainments. Configurations of four or five subcontainments would require operationally impractical ponding conditions during critical flow periods, and six subcontainments would not allow sufficient surface area for effective sedimentation.

Guide curve

132. A guide curve was developed (Figure 11) for the three-subcontainment configuration to determine the approximate ponding depth along the western dike needed to produce the required ponded area for effective sedimentation. This curve is based on an average surface slope of 5 ft in 10,000 ft. Local depressions caused by trenching or erosion should not be considered in determining the ponded depth.

Weir Design

133. Completion of main retaining dikes to el +30.0 ft will require benched alignments, and, therefore, new weir structures. Also, the completion of subcontainments will increase the weir loading (flow rate per unit length) now experienced by the existing weirs. This section outlines a design for the required weir structures considering selective withdrawal characteristics, flow rates, and location. Completion of the three-subcontainment configuration is assumed (see discussion in Part V).

Effective weir length

134. Weir structures must be designed to selectively withdraw the more clarified upper layers of ponded water in order to maintain acceptable water quality. An effective weir length, L_e , defined as the minimum width through which the flow must pass, must be provided to meet this requirement. A design nomogram (Walski and Schroeder 1978) for saltwater sediments has been devised relating effective weir length, inflow rate, ponding depth, and effluent suspended solids concentration (see Figure 62). The nomogram is designed to select weir length based on known values of inflow rate and defined values of effluent suspended

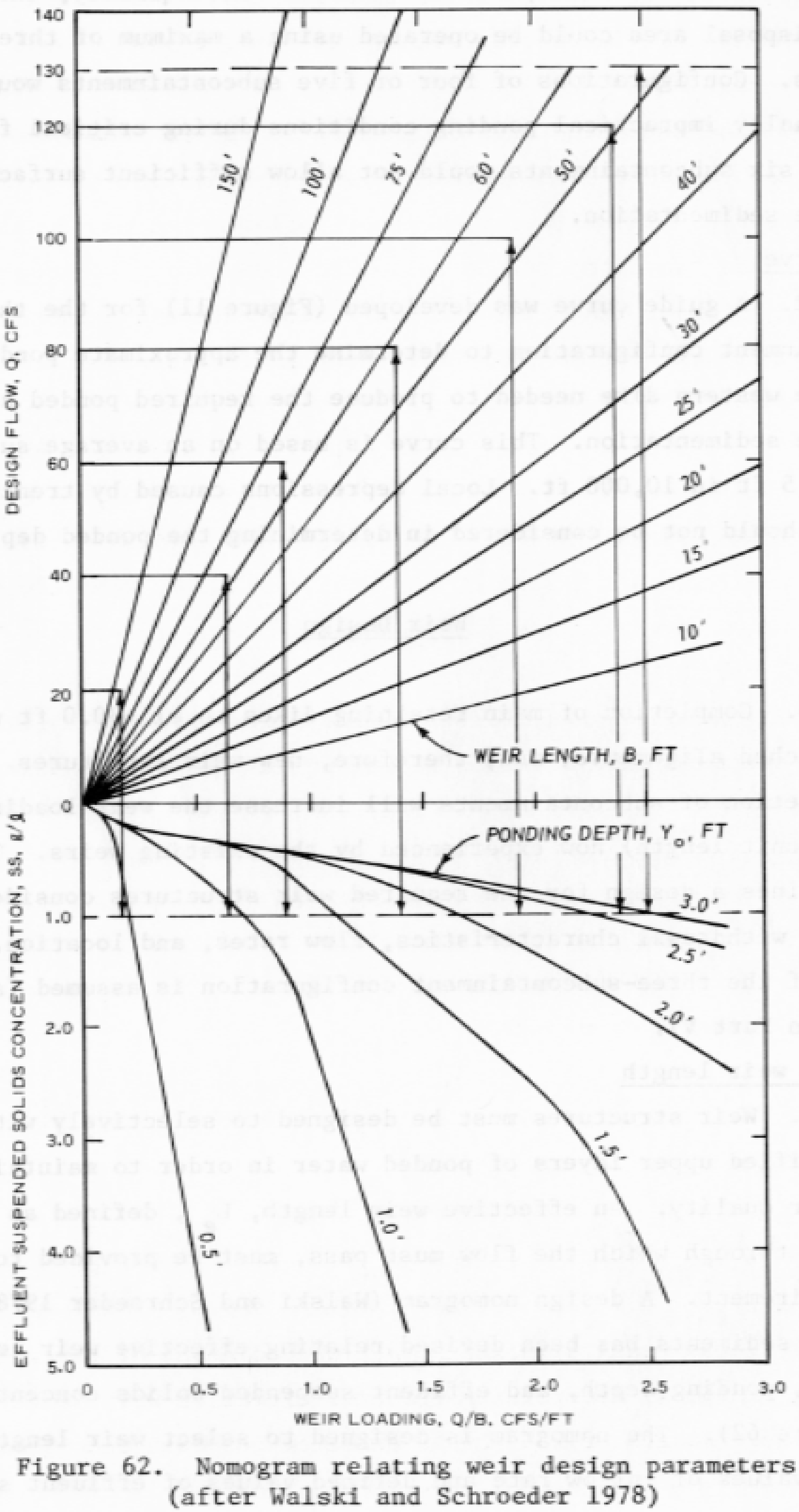


Figure 62. Nomogram relating weir design parameters (after Walski and Schroeder 1978)

solids. However, for the Craney Island disposal area, a range of inflow rates is possible. Therefore, weirs were designed based on a possible range of conditions.

135. The required depth of ponding along the west dike to provide ponded areas for effective sedimentation is a function of inflow rate (see Figure 11). Therefore, a range of inflow rates was considered for weir design as tabulated in the following paragraph. Although effluent suspended solids of less than 1 g/ℓ are desirable and attainable, that value was selected for use with the nomogram in order to clearly distinguish the effect of ponding depth on weir design.

136. The bottom portion of the nomogram was entered with an effluent suspended solids level of 1 g/ℓ and a ponding depth (taken from Figure 11) corresponding to the inflow rate under consideration. A vertical line was then extended. The top portion of the nomogram was then entered with the inflow rate. The required effective weir length was determined at the intersection of the vertical and upper horizontal lines. This design approach results in a range of weir lengths compatible with corresponding required ponded areas. Results are indicated in Figure 62 and are tabulated as follows:

Q_i, cfs	Ponding Depth Required to Produce Area Required for Settling ft	Weir Length ft
20	0.44	125
40	0.89	65
60	1.34	70
80	1.78	58
100	2.23	53
120	2.67	53
130	2.90	53

137. These results indicate that ponded depth at the weir is an overriding factor in determining required effective weir lengths. An effective weir length of 150 ft was selected for design to provide

satisfactory withdrawal characteristics for the anticipated range of flow and ponding conditions.

Depth of flow over weirs

138. The depth of flow in inches, h, over a rectangular weir is given by

$$h = (0.85)\ 0.3 \left(\frac{Q}{L}\right)^{2/3} \tag{4}$$

where

Q = flow rate

L = weir length

The variation of h with L for a design flow of 130 cfs is given below:

L, ft	h, in.
50	8.7
100	5.4
150	4.2
200	3.4
250	3.0

A total weir length of 150 ft, equal to the design effective weir length, results in a depth of flow over the weir slightly greater than 4 in. This value should not result in excessively high structural forces on the weir. Two weirs each with an effective width of 75 ft (total effective length of 150 ft) are recommended. Two such weirs in each subcontainment (for a three-subcontainment configuration) would meet both hydraulic and water quality criteria for all anticipated flow rates.

Location and design of weirs

139. Weirs should be located near the corners of the cell. Jutting weirs might be used with a long side of 50 ft and ends of 12.5 ft. An alternate plan would be to place the weirs across the corners of each cell (Figure 63). This configuration would allow greater flexibility than a single large weir and might result in greater hydraulic efficiency

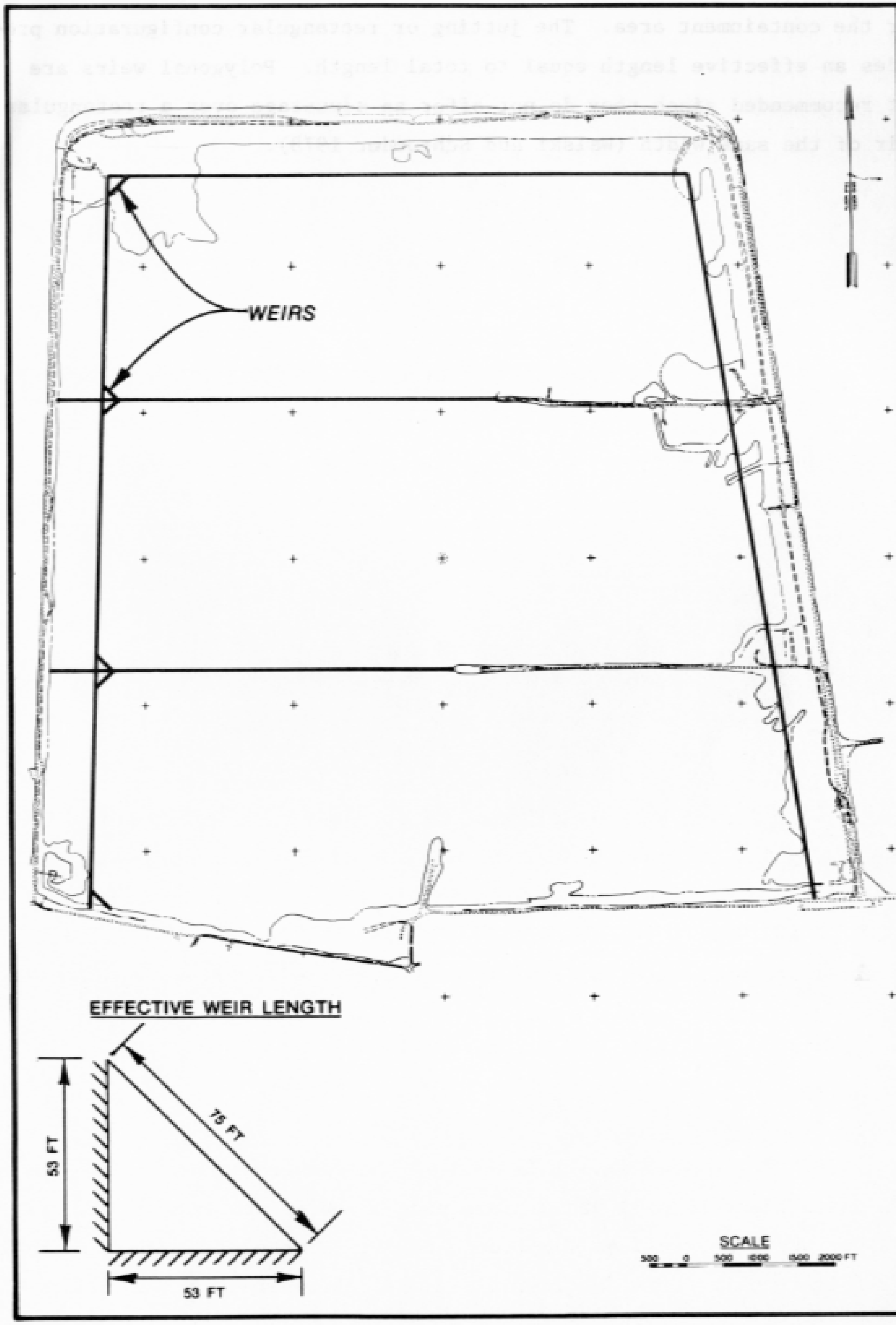


Figure 63. Recommended weir locations

for the containment area. The jutting or rectangular configuration provides an effective length equal to total length. Polygonal weirs are not recommended since they do not offer an advantage over a rectangular weir of the same width (Walski and Schroeder 1978).

PART V: STORAGE CAPACITY EVALUATION

140. Storage capacity of a containment area may be defined as the total volume available to hold additional dredged material and is equal to the total unoccupied volume minus the volume associated with ponding requirements and freeboard requirements. Several factors influence storage capacity: properties of sediments to be dredged, foundation conditions, operational procedures, and containment area management. This section of the report describes how alternative operational and management practices and other factors influence storage capacity at the Craney Island disposal area. Descriptions are given of necessary data, assumptions required, procedures used, and results concerning projections of storage capacity for future years for various alternatives. Projections of storage capacity for future years allow determination of useful service life of the facility for the various alternatives.

Storage Capacity Limitations

141. The limit of storage capacity at Craney Island disposal area is not based on a given volume of material dredged, or a finite time period for disposal activities. Rather, storage capacity is limited only by the height of the dredged material fill. This limit is set by either foundation stability considerations or by social/political factors.

142. Foundation analyses performed to date indicate that a surface elevation for the dredged material fill of approximately +30.0 ft is acceptable from a stability standpoint. References to fill elevations higher than this limiting elevation are predicted on the assumption that later analyses would indicate that higher elevations are acceptable. This assumption relies on the concept that weak and compressible soils such as those marine clays underlying the Craney Island retaining dikes and dredged material within the site tend to gain strength with time upon loading.

Consideration of Subcontainments

143. The effect of various interior dike configurations on water quality of effluent has been previously described in Part IV. Interior diking will also affect storage capacity by confining ongoing disposal operations to one portion of the site while allowing other portions to undergo consolidation and drying. Interior dike configurations corresponding to 2, 3, 4, and 6 subcontainments were evaluated for storage capacity. A projection of storage capacity was also made for the present configuration with partially completed interior dikes. Figure 60 illustrates the subcontainment configurations considered.

Management Alternatives

144. Three management alternatives were considered for the subcontainment configurations described above. The alternatives are as follows:

- a. No change in operations (alternative 1).
- b. Active management of surface water for subcontainments (alternative 2).
- c. Active management of surface water and active surface drainage for dewatering (alternative 3).

145. Under each of the management alternatives, the active cycle, during which disposal operations are ongoing, would be essentially the same. The difference between alternatives lies in actions taken during the inactive cycles between dredging operations.

146. Under alternative 1, the disposal area would be operated and managed essentially as it has been in past years. Interior dikes would be left in place to segregate flows in the eastern portion of the site but not completed.

147. Under alternative 2, interior dikes would be constructed so as to completely divide the disposal area into subcontainments. Opportunity would be afforded to remove all ponded water from subcontainments during inactive cycles to allow a higher effective drying rate.

148. Under alternative 3, subcontainments would be constructed as in alternative 2 and ponded water removed during inactive periods. In addition, active measures would be taken to construct a surface drainage system, increase drying rates, and thereby further dewater and densify the dredged material.

Factors Affecting Storage Capacity

Dredged material and foundation consolidation

149. After dredged material is placed within a containment area, it undergoes sedimentation and self-weight consolidation, resulting in gains in storage capacity. The placement of dredged material also imposes a loading on the containment area foundation; therefore, additional settlement may result due to consolidation of compressible foundation soils. Settlement due to consolidation is therefore a major factor in the estimation of long-term storage capacity. Since the consolidation process is slow, especially in the case of fine-grained materials, total settlement for a given lift will not have taken place before the containment area is required for additional placement of dredged material. For this reason, the time-consolidation relationship is also an important consideration in estimating long-term containment area storage capacity. Evaluation of dredged material and foundation consolidation was accomplished as part of the overall storage capacity evaluation using procedures contained in TR DS-78-10 (Palermo, Montgomery, and Poindexter 1978). Parameters for consolidation were considered identical for each of the management alternatives considered.

Desiccation due to evaporation

150. Since portions of the Craney Island disposal area are exposed to drying, some additional subsidence due to desiccation of material will take place, even in absence of active dewatering efforts. Three factors affect desiccation: (1) evaporation rates, (2) area exposed to evaporation, and (3) time of exposure.

151. The evaluation of desiccation was based on principles

outlined in TR DS-78-11 (Haliburton 1978). Desiccation was found to be the overriding factor in comparison of storage capacity between the various management alternatives considered. Additional discussion of evaporation/desiccation as related to dredged material dewatering is presented in Part VI.

Dredged material dewatering

152. Active dewatering programs are implemented to assist the natural process of evaporative drying. The optimum approach to dewatering is to encourage the rapid removal of precipitation so that infiltration is kept to a minimum and the full annual evaporation rate is utilized for dewatering. This is partially accomplished through good surface water management but may additionally require installation and maintenance of a surface drainage system. This assumption was made in evaluation of alternative 3. Detailed discussion of the methods employed, and the effect of dewatering mechanisms on storage capacity, are found in Part VI.

Reclamation and use

153. Removal of coarse-grained material for use offsite and reclamation of fine-grained material for dike upgrading onsite will restore storage capacity. However, the volumes involved are quite small in comparison to total volumes of material placed within the disposal area. Furthermore, potential for increasing volumes removed offsite is limited. Therefore, reclamation and removal of material were not considered in projecting overall storage capacity of the disposal area. Detailed discussion of material reclamation and use is found in Part VII.

Mathematical Model

154. Evaluation of storage capacity requires the prediction of consolidation/desiccation behavior of material placed within the containment area over a long time period. Also, the number of management alternatives and subcontainment configurations requiring evaluation and the complex nature of disposal operations result in a significant computational effort. Therefore, a mathematical model was employed to more

efficiently evaluate projections of storage capacity versus time.

155. A modified version of the PROCON model (Johnson 1976) was employed for the evaluation of storage capacity. The computer code is available in the time-sharing mode on the WES GE-635 computer and can be easily converted to other automatic data processing systems. The basic PROCON model calculates settlements of newly placed dredged material and foundation soil on the basis of dissipation of excessive pore water pressure according to standard theory of one-dimensional (1D) primary consolidation. A special explicit finite difference numerical technique is applied to solve the 1D differential equation for primary consolidation. The model contains provisions to permit settlement predictions for (a) dredged material that increases in thickness with time from periodic disposal operations, and (b) variations in time intervals between disposal operations.

156. The code is capable of computing the excess pore pressure distribution, average degree of consolidation, and settlement of dredged material and layered foundation soil strata of flooded containment areas. Time intervals for placement of dredged material during a single disposal operation and between disposal operations may be varied. The consolidation parameters of the dredged material may be input as a function of the effective stress to permit improved simulation of actual field conditions. The consolidation parameters of the foundation soils are assumed constant.

157. The basic model was modified to account for desiccation of dredged material due to evaporation. This mechanism was added to the model using basic equations found in TR DS-78-11 (Haliburton 1978).

Selection of Parameters

158. Data requirements for evaluation of storage capacity using the modified PROCON model include:

- a. Time sequence of disposal operations.
- b. Lift thickness for disposal operations.
- c. Consolidation properties of foundation soils and existing dredged material layers.

d. Consolidation properties of sediments to be dredged.

e. Desiccation properties of sediments to be dredged.

Time sequencing of disposal operations

159. Time sequencing for periods of active disposal operations and periods of consolidation/drying for any given subcontainment is dependent upon the number of subcontainments being considered and the time period selected for alternating between subcontainments.

160. Considering the annual period available for desiccation as described in this paragraph, and the time periods required to rehabilitate and raise dike sections, it is not feasible to alternate disposal between subcontainments more often than on an annual basis. Such a time sequencing would ensure full utilization of higher desiccation rates during inactive periods and would allow sufficient time to prepare respective subcontainments for the next active disposal cycle. Also, location of maintenance dredging, required scheduling, and distances to required points of inflow are more suited to an annual sequencing between subcontainments. For these reasons, only annual time sequencing (i.e. alternating annually between respective subcontainments) was considered in the storage capacity evaluations.

Lift thicknesses

161. Determination of lift thickness is a function of the time required for dredging, volume available for disposal, volume of channel material being dredged, and the relationship between in situ channel volumes and volumes occupied immediately after disposal. In situ channel volumes dredged for past years were available from existing records (Appendix A). Though the projected dredging requirements 1980-1992 (Table 1) indicate some variation on an annual basis, an average of 5 million cu yd per year was assumed as an in situ channel volume to be dredged in future years.

162. The relationship between in situ channel and disposal area conditions was determined using procedures found in TR DS-78-10 (Palermo, Montgomery, and Poindexter 1978). Void ratios computed from in situ

water contents of sediment grab samples and results of 15-day column sedimentation tests performed on bulk sediment samples were used to estimate average void ratios in-channel and at the completion of dredging operations. The average period of dredging operations is 9 months per year, implying an average age for the annual deposit of 4-1/2 months at the completion of the active dredging period. Void ratios representative of in situ channel conditions, e_i, may be computed using void ratios of the bulk sediment samples for which column sedimentation tests were run. Values of C_d, the solids concentration in g/ℓ at completion of dredging, are developed from the time versus concentration curves as shown in Figure 46. The average void ratio of dredged material in the disposal area at completion of the lift, e_o, is computed as follows:

$$e_o = \frac{G_s \gamma_w}{\gamma_d} - 1 \tag{5}$$

where

e_o = void ratio in disposal area at completion of the dredging period

γ_w = density of water, g/ℓ

γ_d = C_d = concentration or density of dredged material at completion of the dredging period, g/ℓ (obtained from column tests)

G_s = specific gravity of solids

163. Void ratios representative of in-channel and in-disposal area conditions are summarized as follows:

Sample	$C_d = \gamma_d$ g/ℓ	e_i	e_o
1-B	265	8.19	9.37
16-B	345	5.52	6.97
31-B	542	4.07	4.07
Avg		5.93	6.80

164. The annual in situ channel volume, V_i, can be used to determine the equivalent disposal area volume, V, as follows:

$$V = V_i\left(1 + \frac{e_o - e_i}{1 + e_i}\right) = 5{,}000{,}000 \text{ cu yd}\left(1 + \frac{6.80 - 5.93}{1 + 5.93}\right) \quad (6)$$

$$V = 5{,}627{,}000 \text{ cu yd}$$

where

V = volume of annual maintenance dredging in the disposal area, cu yd

V_i = volume of annual maintenance dredging in situ channel, cu yd

and other terms are defined above.

165. The equivalent lift thicknesses can be directly determined using areas available for dredged material placements. These data are summarized in the following tabulation:

Number of Subcontainments	Area* acres	Lift** Thickness feet	Frequency of Placement years
1 (existing conditions)	2260	1.4	
2	1130	2.8	2
3	753	4.2	3
4	565	5.6	4
6	376	8.4	6

* Area of each subcontainment based on dike alignments required for placement of dredged material to elevation +30.0 ft.

** Lift thickness based on an assumed annual maintenance volume of 5 million cu yd (in-channel volume), which would occupy approximately 5,627,000 cu yd (representative of average state of consolidation at the end of the active period of disposal).

In actual operation, lift thicknesses would vary according to actual volumes dredged. However, over extended time periods the volumes occupied would be essentially identical to those resulting from an application of equal lift thicknesses.

Consolidation parameters

166. Selection of consolidation parameters for sediment and

in-place dredged material was based on results of the consolidation tests described in Part III. Parameters for foundation soils were selected based on the original disposal area design data (Norfolk District 1953).

167. The PROCON model requires consolidation parameters for sediments to be dredged in the following forms:

$$c_v = A + B \log_{10} P \tag{7}$$

$$\log_{10} k = A + B \log_{10} P \tag{8}$$

$$m_v = A + B \log_{10} P \tag{9}$$

where

c_v = coefficient of consolidation, in.^{2}/day

k = coefficient of permeability, cm/sec

m_v = coefficient of volume change, in.^{2}/lb

P = effective pressure, lb/in.^{2}

A and B = model input parameters for which the appropriate coefficients may be computed for the effective pressure existing at a given point

168. The input parameters A and B for the sediment were determined by least squares fit of the consolidation data as shown in Figures 49, 51, and 53. The results are tabulated as follows:

	A	B
Coefficient of consolidation (Equation 7), c_v	6.8517	0.0
Coefficient of permeability (Equation 8), k	-6.5370	-0.5506
Coefficient of volume change (Equation 9), m_v	0.2350	-0.2950

169. Consolidation parameters for foundation soils are taken as average values with no allowance for variation with effective pressure.

The in-place dredged material was considered to be a foundation soil for purposes of this analysis. Consolidation of foundation soils below el -60.0 ft was not considered. Values are tabulated as follows:

Foundation Soil	Elevation ft From	Elevation ft To	c_v in.^{2}/day	k cm/sec	m_v in.^{2}/lb
Dredged material	+15.0	-10.0	5.47	2.34×10^{-7}	0.071
Foundation Zone A	-10.0	-30.0	0.47	5.40×10^{-7}	0.017
Foundation Zone B	-30.0	-60.0	0.67	2.4×10^{-7}	0.015

Desiccation parameters

170. Evaporation of excess water results in desiccation of the dredged material surface, formation of a dry crust, and subsidence of the dredged material surface elevation. The effective rate of evaporation is directly related to the degree of infiltration of precipitation occurring during the period of drying and the area exposed to drying.

171. Annual precipitation and evaporation data for the Norfolk area are summarized in Table 8. These data indicate a 7-month period in which the rate of evaporation exceeds precipitation. During periods when evaporation rate exceeds the precipitation rate, desiccation will occur over exposed portions of the disposal area not covered by ponded water, regardless of infiltration rate.

172. For alternative 1 (continue present mode of operation), the area exposed to drying is dependent upon the number of active disposal operations ongoing at any given time. Approximate ponding conditions were assumed for this alternative as follows:*

	Percent of Total Area Ponded	Percent of Annual Period
No disposal	20	25
One active disposal operation	30	25
Two or more active disposal operations	40	50

* Personal comunication, Mr. Rivers Wescott, Navigation Branch, Norfolk District.

Table 8

Average Monthly Precipitation and Pan Evaporation Rates for the Norfolk, Virginia, Area

Month	Precipitation* in.	Pan Evaporation** in.	Excess Evaporation, in. 100% Infiltration	Excess Evaporation, in. 75% Infiltration
January	3.4	0.0	--	--
February	3.3 6.7	0.6 .6	--	--
March	3.4 10.1	1.0 1.6	--	--
April	2.7 12.8	4.5 6.1	1.8	2.4
May	3.3 16.1	7.0 13.1	3.7	4.5
June	3.6 19.7	7.7 20.8	4.1	5.0
July	5.7 25.4	7.7 28.5	2.0	3.4
August	5.9 36.3	6.6 35.1	0.7	2.2
September	4.2 40.5	4.9 40.0	0.7	1.7
October	3.1	3.6	0.5	1.3
November	2.9	1.2	--	--
December	3.1	0.0	--	--
Total	44.6	44.8	13.5	20.5

* From records of climatological data, Norfolk, Virginia.
** From combined records at Norfolk and Holland, Virginia.

These conditions were used to develop an effective ponded area over which no desiccation would occur.

173. The rate of evaporation for alternative 1 was determined by comparison of field survey data with model predictions as described in the following paragraphs. This analysis indicated an approximate infiltration rate of 75 percent in the years 1957-1979.

174. For alternative 2 (subcontainments completed and surface water managed), the effective evaporation rates will differ for active and inactive dredging cycles. It was assumed that for active dredging cycles, ponded area is a function of required ponding depths as described in Part IV. For inactive cycles, it was assumed that water could be prevented from ponding during the entire drying period. An infiltration rate of 75 percent was also assumed for this alternative.

175. For alternative 3 (subcontainments completed, surface water managed, and active dewatering), ponding conditions were assumed identical to alternative 2. However, the full evaporation rate was assumed to be effective for drying.

176. Rates of water loss, thickness of dredged material desiccated, and rates of surface subsidence were computed using relationships contained in TR DS-78-11 (Haliburton 1978). Further discussion of the desiccation mechanism is presented in Part VI. A summary of the desiccation parameters used in the model projections for storage capacity is presented in Table 9.

Storage Capacity Evaluations

177. Projections of average surface elevation versus time were developed using the PROCON model for a simulation of filling operations 1957-1979 and for alternatives 1 through 3 with various subcontainment configurations. The elevations refer to average surface elevation over the entire disposal area or within a representative subcontainment. Identical relationships for other subcontainments may be developed by simply offsetting the projections according to the time at which disposal is initiated.

Table 9

Water Loss and Surface Subsidence Rates Due to Desiccation

Alternative	Number of Subcontainments	Dredging Cycle	Water Loss* in./year	Surface Subsidence* in./year
1 (continue present mode of operation)	1	--	4.8	4.0
2 (subcontainments completed, surface water managed)	2,3,4	Active	4.3	3.6
		Inactive	7.2	6.0
	6	Active	2.2	1.8
		Inactive	7.2	6.0
3 (subcontainments completed, surface water managed, and active dewatering)	2,3,4	Active	4.3	3.6
		Inactive	14.7	12.2
	6	Active	2.2	1.8
		Inactive	14.6	12.1

* Water loss and surface subsidence rates were determined using equations contained in TR DS-78-11 (Haliburton 1978), modified to account for surface areas and times of inundation for the various alternatives considered.

Filling simulation 1957-1979

178. The existence of periodic field survey data and extensive dredging records allowed a simulation of filling operations from 1957 to 1979. The preceding paragraphs described the complex nature of estimating future storage capacity relationships for a large disposal area such as Craney Island. A comparison of filling simulations using the PROCON model with actual field data served as a model calibration, lending increased validity to projections of future storage capacity relationships. A major parameter selected using the filling simulations was the infiltration rate for precipitation which dictates the water loss and surface subsidence rates due to desiccation (for alternatives 1 and 2).

179. Appendix A tabulates the in situ channel volumes dredged by years 1957 to 1979. Equation 6 was used to compute equivalent volumes in the disposal area at the end of each annual dredging period. Knowing the area available for disposal, equivalent annual lift thicknesses were computed and are indicated in Figure 64. The PROCON model was then used to simulate the increase in surface elevation versus time due to the filling operation.

180. Consolidation parameters assumed for sediments and foundation soils as determined by laboratory tests and described previously were used for the simulation. The model results were compared to average disposal area surface elevations determined by topographic surveys as described in Part II and presented in Appendix B. The average elevation over the entire disposal area for each survey is indicated in Figure 64. Infiltration rates and corresponding desiccation rates were varied, assuming ponding conditions as described previously, until the model filling simulation closely approximated actual field conditions. The surface elevation versus time relationships for no desiccation (consolidation only) and desiccation corresponding to 100 and 75 percent infiltration are shown in Figure 64. Based on these results, an effective infiltration rate of 75 percent was selected as representative of field conditions under the present mode of operation. As seen in

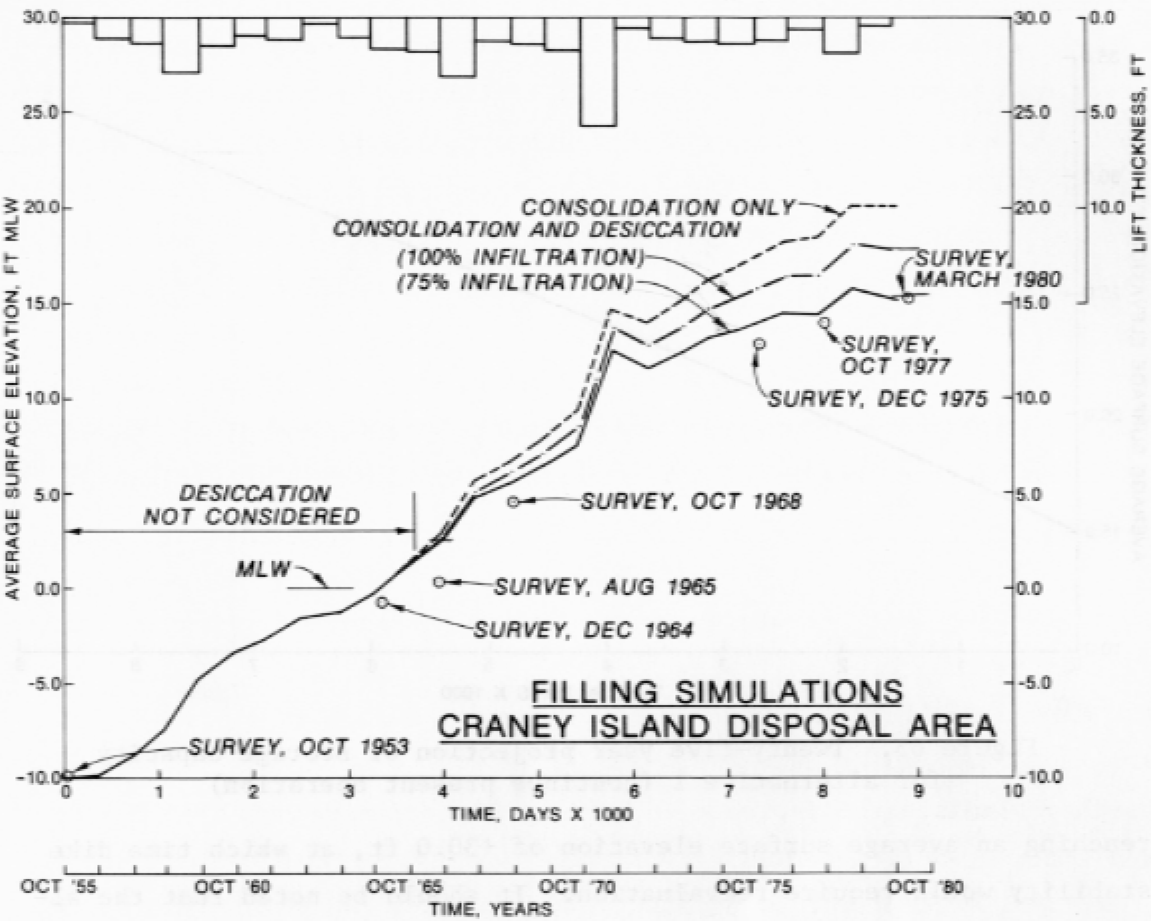


Figure 64. Simulation of filling operations 1957-1979

Figure 64, this is a conservative assumption, slightly underpredicting actual field consolidation/desiccation.

Comparison of alternatives

181. A 25-year projection of future storage capacity was selected for comparison of the various alternatives and subcontainment configurations. Parameters selected for consolidation, desiccation, rates of filling, and time sequencing have been described previously. The projections assumed present conditions as a starting point with the dredged material surface elevation at +15.0 ft.

182. Results for alternative 1 (continue present mode of operation) are indicated in Figure 65. This relationship indicates that the disposal area could be operated for approximately 19 years before

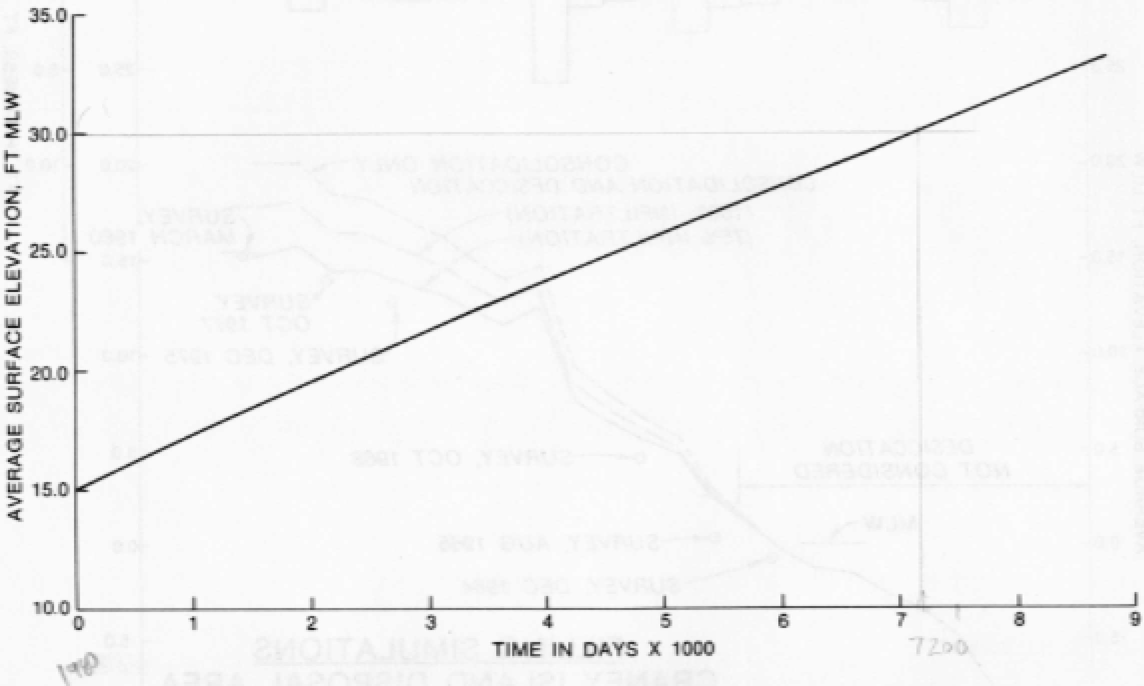


Figure 65. Twenty-five year projection of storage capacity for alternative 1 (continue present operation)

reaching an average surface elevation of +30.0 ft, at which time dike stability would require reevaluation. It should be noted that the almost linearly increasing relationship is due to the constant rate of filling assumed, and that the rate of filling (slope) correlates well with that for the filling simulation 1957-1979.

183. Results for alternative 2 (subcontainments completed and surface water managed) are shown in Figure 66. The sawtooth shape of the projection is indicative of the alternating cycles of filling and drying which vary in length according to the number of subcontainments under consideration. Similar results obtained for alternative 3 (subcontainments completed, surface water managed, and active dewatering) are shown in Figure 67.

184. The average surface elevation at the end of the 25-year projection for each alternative is shown in Figure 68. This comparison indicates an approximate 12 percent savings in storage capacity over the 25-year period if the disposal area is subdivided and surface water

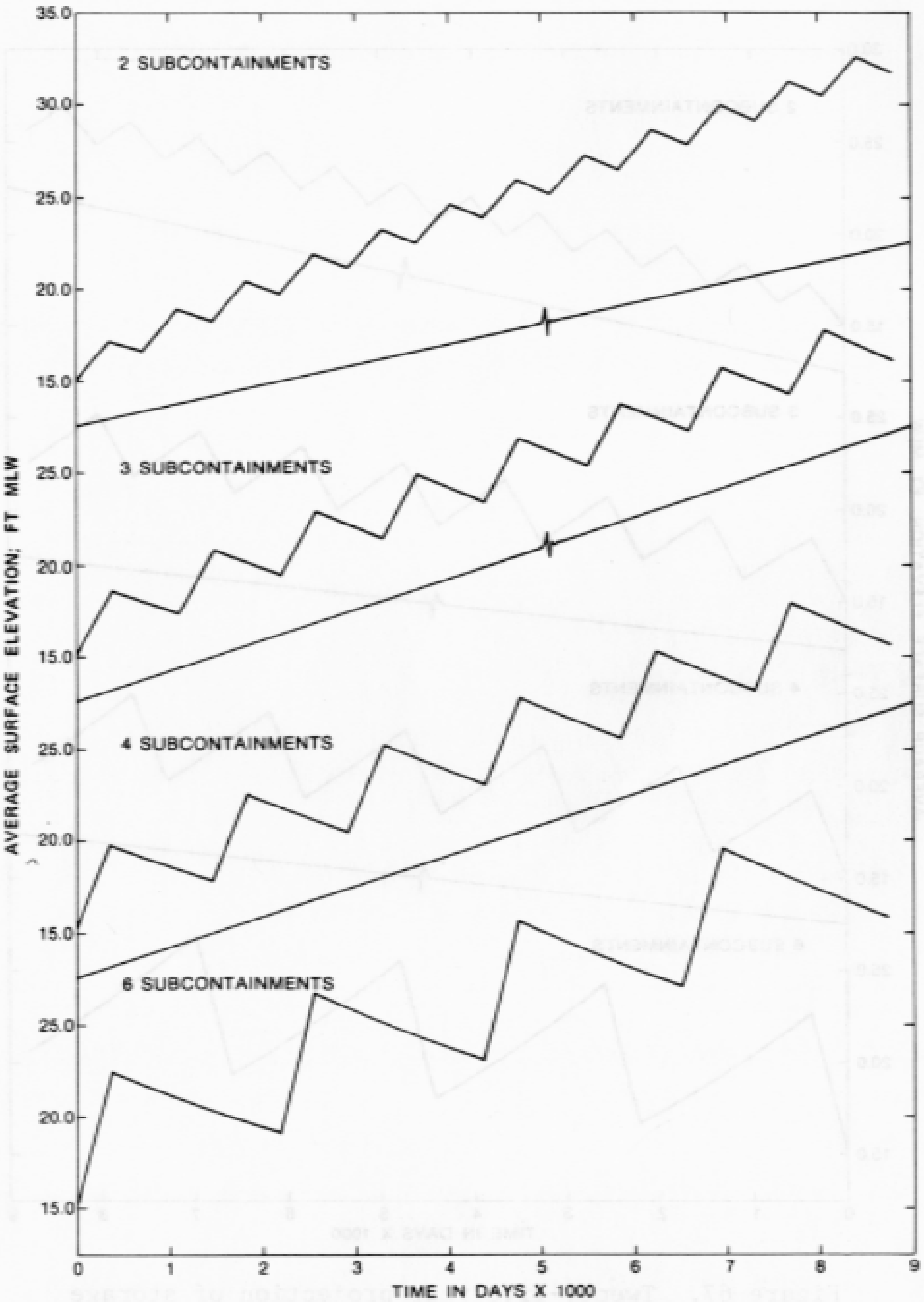


Figure 66. Twenty-five year projection of storage capacity for alternative 2 (subcontainments with surface water management)

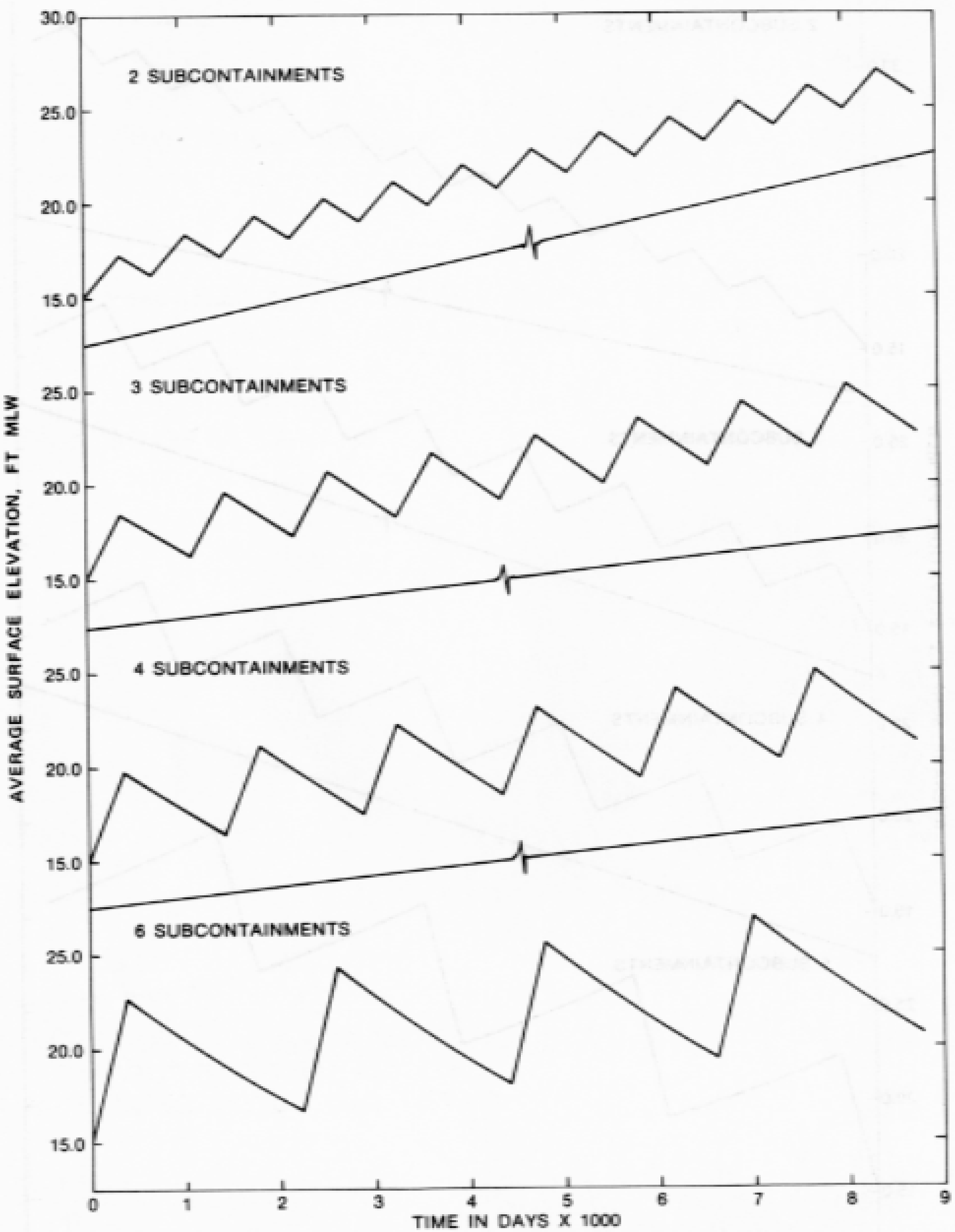


Figure 67. Twenty-five year projection of storage capacity for alternative 3 (subcontainments with surface water management and active dewatering)

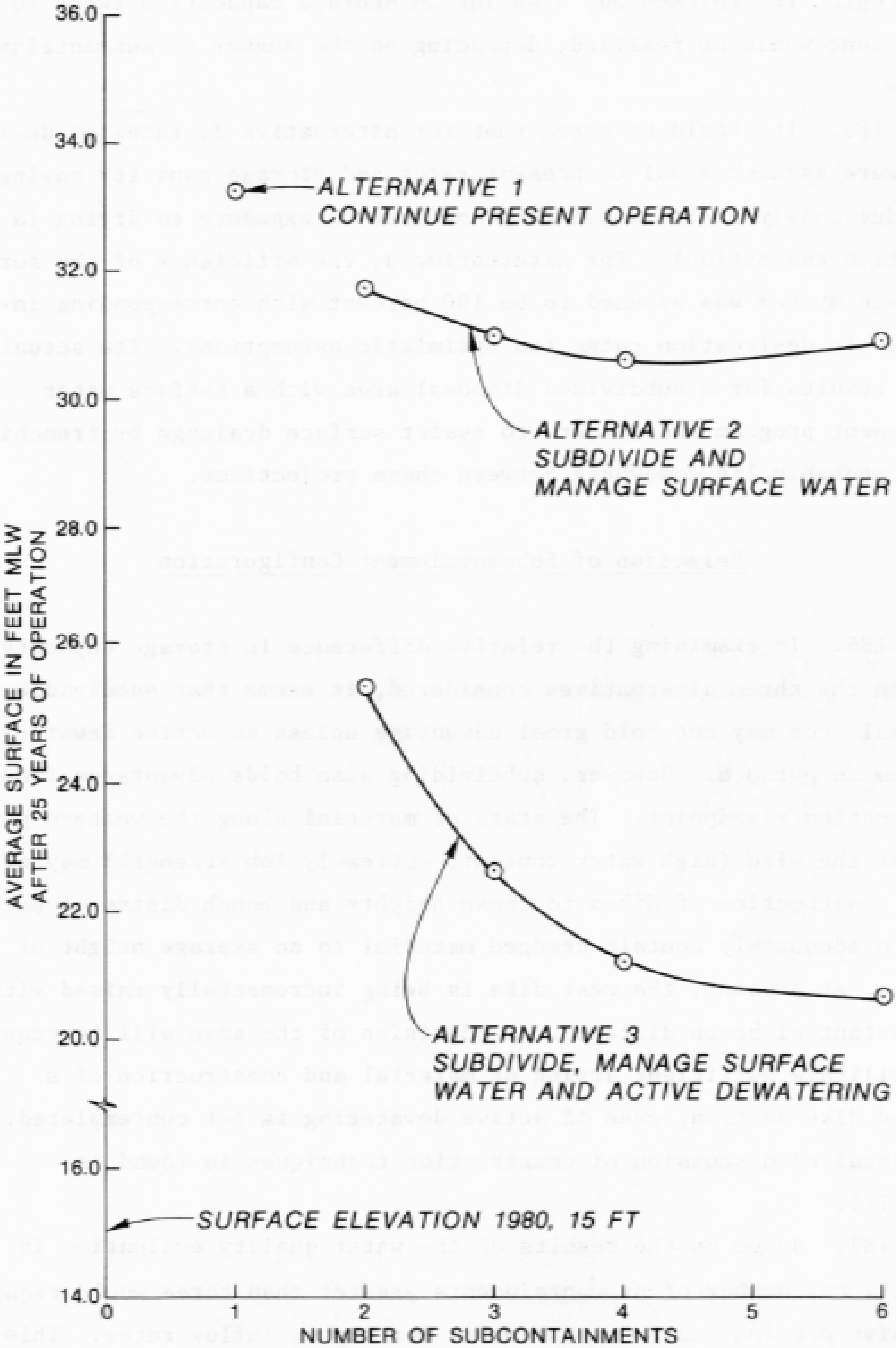


Figure 68. Average surface elevation after 25 years as related to subcontainment configuration

is managed during inactive cycles. Additionally, if an active dewatering program is implemented, a saving in storage capacity between 40 and 65 percent would be realized, depending on the number of subcontainments in use.

185. It should be noted that for alternative 2, rates of desiccation were assumed equal to present rates and storage capacity savings were due solely to increased time and area of exposure to drying (a conservative assumption). For alternative 3, the efficiency of the surface drainage system was assumed to be 100 percent with corresponding increases in desiccation rates (an optimistic assumption). The actual field results for a subdivided disposal area with a surface water management program and efforts to assist surface drainage by trenching would probably lie somewhere between these projections.

Selection of Subcontainment Configuration

186. In examining the relative difference in storage capacity between the three alternatives considered, it seems that subdividing the disposal area may not hold great advantage unless an active dewatering program is pursued. However, subdividing also holds advantages from a construction standpoint. The state of material along the western portion of the site (high water content, extremely low strength) may not allow construction of dikes to those heights and bench distances necessary to adequately contain dredged material to an average height of +30 ft. At present, the west dike is being incrementally raised with no substantial bench distance. Subdivision of the area will be required to facilitate sufficient drying of material and construction of a benched dike section, even if active dewatering is not contemplated. More detailed discussion of construction techniques is found in Part VIII.

187. Based on the results of the water quality evaluation in Part IV, any number of subcontainments greater than three would require excessive ponding depths at the weirs for higher inflow rates. This sets a practical upper limit for the selected number of subcontainments.

From the standpoint of storage capacity, the optimum number of subcontainments is four or more, considering both management of surface water and active dewatering.

188. Although four subcontainments may seem to be the optimum choice from a technical standpoint, the selection of three subcontainments is preferable from a construction standpoint. The small advantage in storage capacity using four subcontainments is more than outweighed by consideration of partially completed interior dikes in the three-subcontainment configuration. Also, three subcontainments would require lesser ponded depths to maintain effluent water quality at higher inflow rates, an advantage from an operational standpoint. Therefore, completion of the three-subcontainment configuration is recommended.

189. Based on the significant increase in storage capacity anticipated, the implementation of an active dewatering program (alternative 3) is also recommended. An extended storage capacity projection for alternative 3 using the recommended three-subcontainment configuration is shown in Figure 69. This projection indicates that the disposal area could be operated and managed under these conditions for approximately 36 years before reaching an average surface elevation of +30 ft, at which time dike stability would require reevaluation. The useful service life under the assumptions of alternative 3 is practically double that for alternative 1.

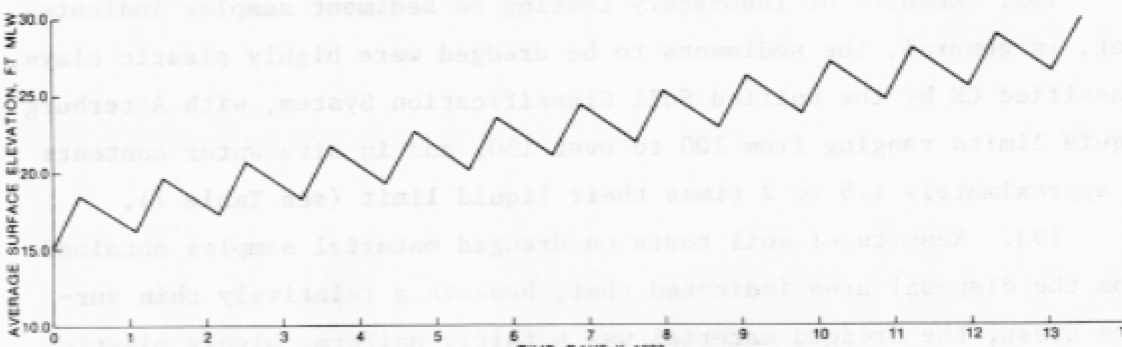


Figure 69. Extended storage capacity projection for three-subcontainment configuration with surface water management and active dewatering

PART VI: DREDGED MATERIAL DEWATERING

190. This part of the report describes techniques for analysis and methods for implementation of an active program of dredged material dewatering at the Craney Island disposal area. A technical evaluation of dewatering alternatives was performed under contract to WES (Haliburton and Hayes 1980). The information in the following subparagraphs is largely taken from this technical evaluation. Analytical procedures used for determining the effects of dredged material dewatering are based on TR DS-78-11 (Haliburton 1978). In addition to direct use of technical equations and prediction methodology contained in the report, suggested guidelines for selection of dewatering parameters were also used.

Assessment of Existing Conditions as Related to Dewatering

191. Test data applicable to the dewatering analysis include the plasticity, natural water content, and consolidation properties of both channel sediment, which will be placed in Craney Island in the future, and existing dredged material already placed within the disposal area. Descriptions of the test data are contained in Part III.

192. Results of laboratory testing on sediment samples indicated that, in general, the sediments to be dredged were highly plastic clays, classified CH by the Unified Soil Classification System, with Atterburg liquid limits ranging from 100 to over 150, and in situ water contents of approximately 1.5 to 2 times their liquid limit (see Table 7).

193. Results of soil tests on dredged material samples obtained from the disposal area indicated that, beneath a relatively thin surface crust, the dredged material was a fairly uniform, highly plastic clay, classified CH by the Unified Soil Classification System, and having Atterburg liquid limits ranging from approximately 50-150 percent (Figures 37-42). The average natural water content to the fine-grained dredged material was at or slightly above its liquid limit,

both for samples obtained in the central portions of the disposal area (nearer the dredge pipe inflow locations) and near the west perimeter dike (nearest the outflow weirs). Atterberg limits for the channel sediment and dredged material were found to be similar. Existence of the in situ dredged material at water contents at or slightly above the liquid limit, even at depths near the original foundation elevation, is consistent with observed behavior for such CH materials found in numerous disposal areas.

194. Based on review of background data, field exploration, and laboratory test results obtained for in situ material, the primary factor inhibiting dredged material drying, by either natural or artificially assisted means, at the Craney Island disposal area is the essentially year-round use of the facility for disposal. In many confined disposal areas, disposal is carried out only for a short period of a few weeks, and then several years may elapse prior to the next disposal operation. During this time, if adequate drainage is provided to remove ponded water and precipitation, considerable dredged material desiccation drying may occur without any other overt management action. However, at the Craney Island site, continual disposal provides enough free water on the surface of the fine-grained material to inhibit desiccation drying and crust formation, except in a few isolated instances during some portions of the year. This conclusion is confirmed by the results of field exploration, which indicated that the fine-grained dredged material on both the east and west sides of the site exists at a water content near its Atterberg liquid limit, the "equilibrium" water content under self-weight consolidation determined for such fine-grained dredged material by DMRP research. This water content-liquid limit relationship was found to exist even for in situ dredged material located immediately above the original site foundation. Based on these considerations, a viable dewatering plan cannot be developed for the Craney Island facility unless the site is subdivided to allow conduct of dewatering activities in one or more portions of the site while disposal, on a year-round basis, is occurring in another portion or subcontainment of the site.

Dewatering Analysis

195. In developing the required assumptions and methodology for evaluating the dewatering alternative, it was assumed that the disposal area would be subdivided. The analytical techniques described in the following paragraphs were used to develop desiccation parameters for the PROCON model used in evaluating storage capacity. Subcontainment configurations corresponding to two, three, four, and six subcontainments were evaluated, assuming an active dewatering program would be implemented.

Assumptions

196. The following assumptions were made regarding desiccation behavior of the fine-grained dredged material:

- a. Approximately 35 percent of the Class A pan evaporation rate is the practical limit of water removal in the saltwater environment at Craney Island.
- b. Dewatering activities could be commenced at the end of the annual disposal cycle in any given subcontainment. The average water content of the dredged material deposit at this time would be approximately 1.4 times the liquid limit, assuming self-weight consolidation and limited desiccation occurring prior to initiation of dewatering.
- c. During the period available for dewatering, an active and aggressive program of surface trenching, generally following guidelines given in TR DS-78-11 (Haliburton 1978), would be carried out, such that essentially continuous second-stage evaporative drying (governed by capillary resupply potential) would occur in the disposal compartment. This assumption corresponds to a 0 percent infiltration of precipitation.
- d. As a result of desiccation, a surface crust would form, with the dried material at a water content of approximately 1.2 times the plastic limit.
- e. After dewatering to crust condition, fine-grained dredged material would undergo essentially minimal further consolidation under weight of dredged material placed in subsequent disposal lifts, and would continue to occupy essentially its dewatered volume.
- f. Prior to the start of dewatering activities, the level of the perched water table inside any disposal compartment was assumed to be at the dredged material surface.

g. If evaporative dewatering dried an entire lift prior to the end of the dewatering interval, effect of dewatering on the crust underlying the lift was nelgected, as this volume gain had already been considered.

Effects of lift thickness

197. Variations of annual dredged volumes will result in corresponding variations in applied lift thickness. As an example, for the three-subcontainment configuration, lift thickness would vary between approximately 3 and 5 ft assuming dredged volumes as shown in Table 1. As discussed in Part V, this variation will have little effect on long-term projections of storage capacity which were based on an assumed constant annual volume of 5 million cu yd. However, lift thicknesses in excess of 5 ft begin to significantly affect desiccation and consolidation behavior.

198. The percent reduction in lift thickness due to consolidation/desiccation is shown plotted versus applied lift thickness in Figure 70. This relationship was developed for the three-subcontainment

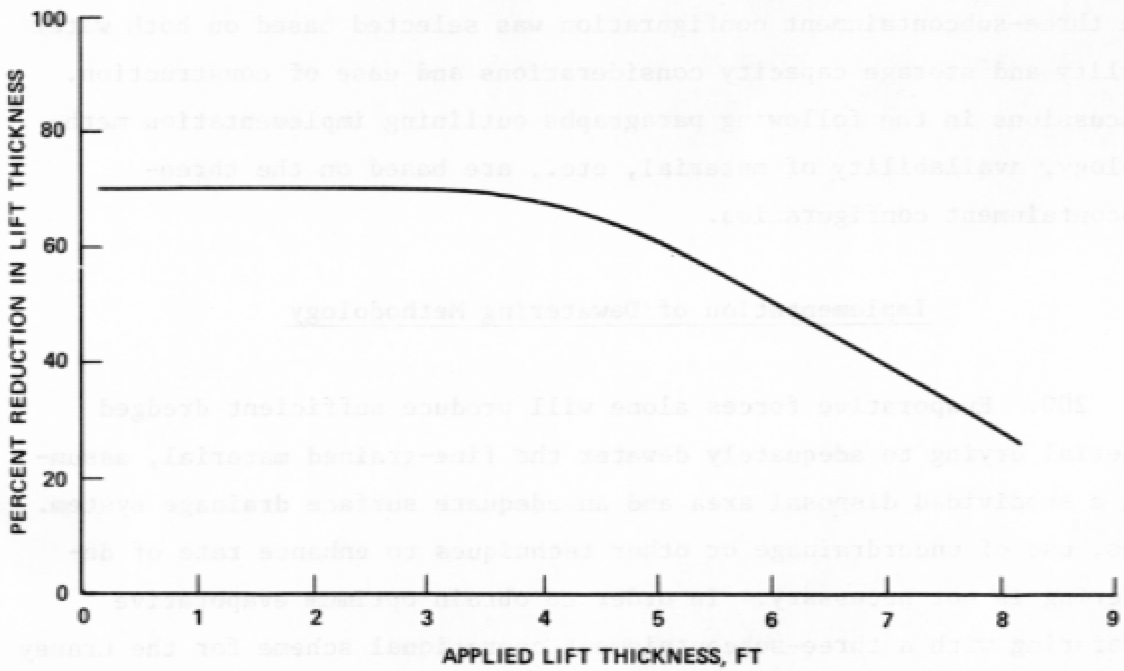


Figure 70. Percent reduction in lift thickness due to consolidation/desiccation versus applied lift thickness for three-subcontainment configuration

configuration using desiccation and consolidation parameters as discussed in Part V. Applied lift thicknesses of 4 ft or less show 70 percent reduction, the optimum benefit attained by dewatering the entire lift. Thicknesses in excess of 4 ft show correspondingly less percent reduction due to the fact that the entire lift is not dewatered in the available drying period. The lift thicknesses applied over any annual period should therefore be limited to approximately 6 ft or less to avoid significant reduction in dewatering benefits.

Consideration of Subcontainments and Evaluation of Storage Capacity

199. The previous assumptions were used to develop desiccation rates for the active dewatering condition. Results of storage capacity evaluations have been previously described in Part V. In addition, projections of storage capacity under these conditions were made using predictive equations contained in Haliburton (1978). These results are available in Haliburton and Hayes (1980). As discussed in Part V, the three-subcontainment configuration was selected based on both water quality and storage capacity considerations and ease of construction. Discussions in the following paragraphs outlining implementation methodology, availability of material, etc., are based on the three-subcontainment configuration.

Implementation of Dewatering Methodology

200. Evaporative forces alone will produce sufficient dredged material drying to adequately dewater the fine-grained material, assuming a subdivided disposal area and an adequate surface drainage system. Thus, use of underdrainage or other techniques to enhance rate of dewatering is not necessary. In order to obtain optimum evaporative dewatering with a three-subcontainment operational scheme for the Craney Island disposal area, two technical problems must be solved:

a. The two partially constructed interior dikes, at the north-south third-points of the disposal area, must be completed to the west perimeter dike to provide the three necessary compartments.

b. An active, continuous, and aggressive program to remove all ponded water from the site during drying cycles must be implemented, or desired dewatering rates will not be obtained.

201. Procedures for construction of interior dikes are described in Part VIII. Concepts for implementing a dewatering program based on effective surface drainage are described in the following paragraphs.

Concept of surface drainage dewatering

202. Prior research (Haliburton 1978; Palermo 1977) has indicated that an effective surface drainage system is the optimum dewatering approach from both a technical and economic standpoint. Drainage trenches placed adjacent and parallel to the dikes and within the disposal area interior, leading to the outflow weirs, would allow rapid runoff of precipitation and prevent water ponding. This would allow evaporative forces to more efficiently dewater the dredged material. Subsequent precipitation runoff will flow through desiccation cracks in the crust to the trenches and, hence, to the weirs and offsite. As drying continues, the crust desiccation cracks become deeper and the depth of site drainage trenches should be progressively increased, so that water will not pond in desiccation cracks, thus the name "progressive trenching" for the process.

Equipment selection

203. Generalized guidance regarding selection of equipment for construction of surface trenches in fine-grained dredged material (Haliburton 1978) indicates that no unique combination of trenching equipment and technique exists. Existing experience in this area has largely been gained by trial and is by no means extensive. Some technical basis for equipment selection based on crust thickness, equipment weight, etc., is available (Willoughby 1977). However, since crust formation rates for the Craney Island disposal area can only be estimated at this time, these criteria cannot alone govern the initial selection of trenching equipment.

204. Based on prior experience and observation of equipment performance, several pieces of equipment can be considered as viable alternatives for conducting an effective trenching program at Craney Island. Final selection of equipment for full-scale operations should be based on field trial.

205. During conduct of research on dredged material dewatering, the Riverine Utility Craft (RUC), a twin-screw amphibious vehicle, was found to be a useful tool in constructing shallow trenches in dredged material at high water content. RUC's would likely be available on a loan basis from WES, the Mobile District, and the Charleston District.

206. While use of a RUC will provide dewatering capability immediately after the end of disposal in a particular subcontainment, other alternatives exist for obtaining satisfactory dewatering without the vehicle. Immediately upon completion of disposal, draglines working from the subcontainment boundary dikes could dig shallow perimeter trenches, connecting to outflow weir(s), casting excavated materials on the perimeter dikes to dry. This technique has been used successfully at Craney Island and would be even more effective if used in conjunction with a subcontainment management approach. These trenches, though shallow, would facilitate dredged material drying near the perimeter dike, and as crust thickness grows, the ditches could be dug to deeper depths, which would facilitate more drying. Subsidence from shrinkage drying near these ditches would also cause a slight dredged material surface elevation gradient, causing drainage from the interior of the site toward the dikes. Repeated dragline trenching would cause progressive crust development, from the perimeter dikes toward the site interior. Photos showing typical stages of perimeter trench construction are presented in Figures 71-75.

207. Trenches leading into the interior portions of the subcontainments would greatly facilitate surface drainage, but these trenches would prove to be more difficult to construct and maintain. Several approaches could be taken. After a minimal crust thickness has formed due to periphery trenching, low-ground-pressure vehicles could pull plows toward the interior, thus forming shallow trenches. Alternatively

Figure 71. Typical initial perimeter trench constructed by dragline

Figure 72. Perimeter trench deepening

Figure 73. Typical deepened perimeter trench

Figure 74. Typical desiccation crust

Figure 75. Well-developed perimeter trench system

the perimeter trenching could simply be continued until crust thickness had sufficiently developed to support amphibious draglines or mat-supported draglines, which could then construct interior trenches.

208. The Rotary Trencher manufactured by Quality Industries, Inc., also holds potential as an effective dewatering tool for the interior portions of the Craney Island disposal area. A photograph of the trencher is shown in Figure 76. This piece of equipment is mounted on an amphibious low-ground-pressure track system specifically designed for operation in marsh areas. Draglines mounted on similar track systems have been successfully used in experimental dewatering programs (Palermo 1977) to create trenches in thinly crusted disposal areas. More detailed specifications for standard models are available in Willoughby (1977) and OCE (1978).

209. Rotary Trenchers have been extensively used for mosquite control activities within marsh areas and diked dredged material disposal areas. In this application, the trencher cuts trenches around the periphery and within the interior of disposal areas to drain ponded

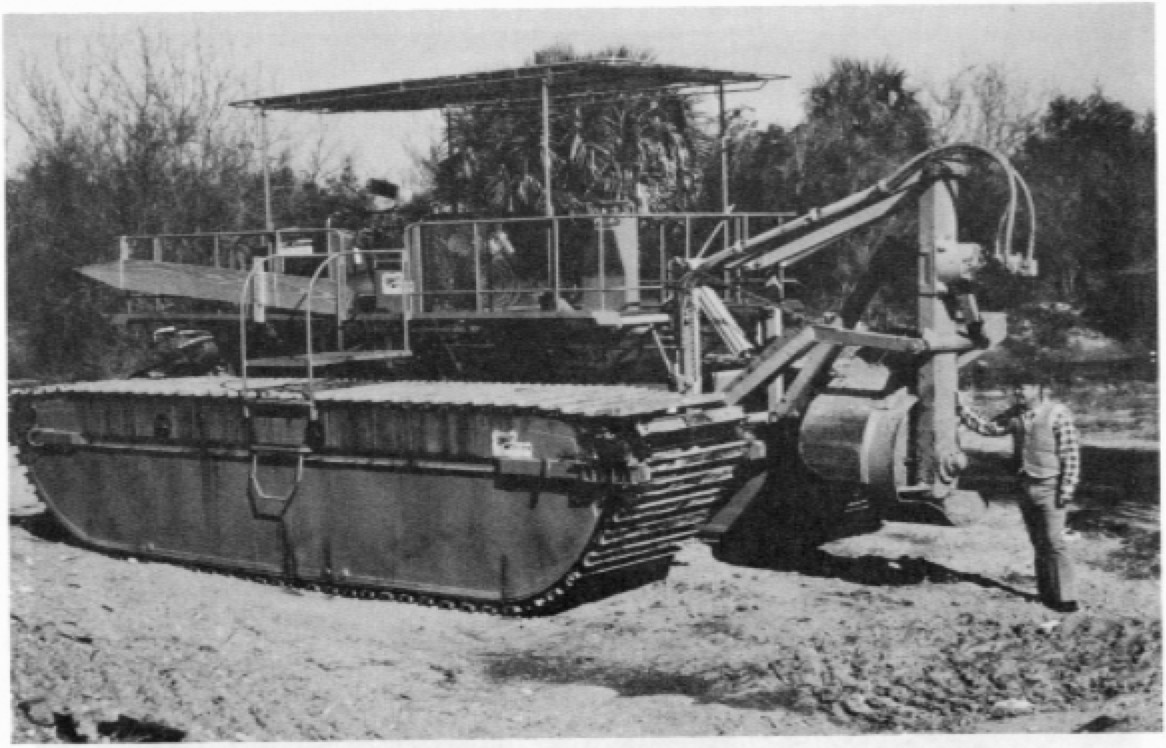


Figure 76. Rotary Trencher used in mosquito control activities

water, thereby discouraging mosquito breeding. Photos of typical trenches are shown in Figures 77a and b. As can be seen in these photographs, the rotary trenching implement cuts a hemispherical trench, slinging the excavated material well away from the cut section. Such a trenching mechanism would be ideally suited for trenching within the Craney Island disposal area for dewatering purposes. Based on past experience, an initial crust thickness of 4 to 6 in. would be required for effective mobility of the equipment. This crust thickness could be easily formed within the first year of dewatering effort if surface water is effectively drained from the area, assisted by perimeter trenches constructed by draglines operating from the dikes.

210. A suggested scheme for perimeter and interior trenching using a combination of draglines and a rotary trencher or other suitable equipment is shown in Figures 12 and 13. Once the disposal area subcontainments are completed and a triennial disposal sequence between subcontainments is initiated, trenching may be accomplished as early as possible in the 2-year inactive cycle. In the first year following

a. General view

b. Closeup view showing desiccation cracks

Figure 77. Appearance of trenches formed by Rotary Trencher

disposal, perimeter trenches would be constructed parallel to the dikes leading to the weir structures. Interior trenches would then be placed in a V-shaped pattern to take advantage of the natural east to west slope. The effective overland flow distance for precipitation is drastically cut, thereby dramatically increasing the proportion of runoff and decreasing the corresponding infiltration.

Availability of Dewatered Material for Dike Construction

211. A large volume of dewatered fine-grained dredged material crust will be developed by the dewatering program. This dewatered crust can be used to supplement available sand and the relatively small amount of dewatered fine-grained dredged material now available in dike-raising activities. In particular, availability of relatively large volumes of dewatered fine-grained dredged material along the west perimeter dike will facilitate widening and raising this dike without the need for more expensive material hauling from other parts of the site. Also, interior dike raising can probably be conducted by direct dragline borrow, with equipment working off the dike, thus minimizing the need for material haulage. Specific construction procedures for borrow and dike construction with fine-grained dewatered dredged material are discussed in Part VIII.

Estimated Costs of Dredged Material Dewatering

212. Exact costs per cubic yard of disposal volume created by dredged material dewatering will depend, in considerable measure, upon the particular equipment chosen to conduct the dewatering, whether or not satisfactory equipment is already available to the Norfolk District, and whether the dewatering effort is conducted by in-house personnel, rental contract, or performance contract. The Norfolk District currently maintains personnel at the Craney Island disposal site to conduct various in-house activities which could be used in an effective trench dewatering program. Also, the Norfolk District currently lets rental contracts for purposes of trench dewatering around the perimeter

dikes, in order to stabilize perimeter areas and allow dike-raising by inward benching. Thus, precedent and expertise in trenching are currently available to the Norfolk District.

213. On a large-scale basis, costs of creating disposal volume by progressive surface trenching range from $0.10/cu yd to $0.30/cu yd (1977 dollars), depending upon the climatological regime, size and configuration of a particular disposal area, type of equipment chosen for use in trenching, and whether the work was conducted in-house or by contract (Haliburton 1978). Cost of perimeter dike-raising using dewatered fine-grained dredged material was found to be approximately $0.25/cu yd-$0.27/cu yd (1978 dollars) in Mobile, Alabama (Haliburton, Fowler, and Langan 1980). While unit costs have increased since these cost data were developed, the relative cost relationship should be approximately the same.

214. The value of disposal capacity at Craney Island may be inferred by the estimated cost of such capacity at contemplated replacement sites. This cost or value was estimated at approximately $0.90/cu yd.* It may thus be concluded that additional disposal capacity at the Craney Island site may be developed, through dredged material dewatering, at a favorable cost compared to constructing a new disposal area at a nearby location.

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* Personal communication with Jim Melchor, Water Resources Planning Branch, Norfolk District.

PART VII: DREDGED MATERIAL RECLAMATION, PRODUCTIVE USE, AND MARKETING

215. Reclamation of dredged material from within a confined disposal area and its subsequent use offsite serves the dual function of partially restoring storage capacity and utilizing available dredged material resources for some productive purpose. Such practices have been used successfully at the Craney Island disposal area on a limited scale. This part of the report describes the potential for increasing the magnitude of dredged material reclamation and productive use as part of the overall management of the Craney Island facility.

Present Practices

Sale and donation of coarse-grained material

216. The Norfolk District has been involved in removal of small quantities of usable coarse-grained material from the disposal site to partially restore capacity. Areas of borrow coincide with the points of inflow shown in Figure 27. The material is usually removed using conventional draglines, as shown in Figure 78. In some cases, scrapers have been used to remove the larger quantities. This indicates that coarser deposits extend well below the surface, supporting information available from the numerous borings taken in the eastern portion of the disposal area. A summary of material sold by volume and date is presented in Table 10. A majority of the material sold has been utilized by local sand and gravel companies. These data indicate a magnitude of material moved offsite on the order of only tens of thousands of cubic yards.

217. Much larger volumes of coarse-grained material have been rehandled and trucked to various locations within the disposal area by the Norfolk District for use in maintenance and upgrading of the main retaining dike, especially the western dike, and the interior spur dikes.

Figure 78. Removal of coarse-grained dredged material from the Craney Island disposal area

Table 10

Summary of Coarse-Grained Material Sold or Donated from Craney Island Disposal Area

Date	Volume cu yd	Bid Price per cu yd $
May 1970	15,000	Lump sum
Oct 1970	4,500	Lump sum
April 1975	7,000	Donation (U. S. Navy)
Feb 1976	21,736	0.30
Sept 1976	13,400	0.30
Oct 1976	300	Lump sum
Oct 1977	2,840	0.50
May 1978	5,811	0.50
Sept 1978	1,015	0.50
Sept 1978	16,475	0.50
Nov 1978	34,030	0.50
Dec 1978	479	0.50
March 1979	25,260	0.50
Sept 1979	18,534	0.50
Dec 1979	32,004	0.50
Dec 1979	3,020	0.50
Dec 1979	2,980	0.50
Jan 1980	1,000	0.50

Use of fine-
grained material

218. Large volumes of fine-grained dredged material have been utilized in constructing the benched dike section used in upgrading the overall dike elevations. This method has been successfully used along the northern and eastern retaining dikes. However, removal of fine-grained material offsite for any known productive use has not been recorded.

Legal and policy constraints

219. Material from Craney Island has been sold as excess real property. The legal and policy position of the Norfolk District regarding sale and donation of material as summarized from available records is as follows:

> For the purpose of sales conducted by [the Norfolk District], the material is treated as real property. Authorization and procedure prompting disposal are the same as those referred to as "sand, clay, gravel and stone-quarried spoil products," and are contained in AR 405-90, ER 405-23-912, ER 405-1-913, and Federal Property Management Regulations, Subchapter H, as amended, Section 101-45, and Section 101-47.103-12. These regulations are available for examination in the [District] Real Estate Division. They make no provision for disposal of the dredged material as a real estate item except by donation to certain qualifying public agencies and by public sale at the appraised current fair market value. Any other method of disposal would require approval by higher authority. ...[the District] is not authorized under current regulations to donate the material to the general public at no cost. For that reason, the plan has never been seriously considered. However, if such plan appears advantageous to the Government, a request for a waiver of existing restrictions, and authority to donate the material to any interested parties, could be forwarded, through channels, to the Office, Chief of Engineers, for consideration. Donation, however, would result in unfair competition with local borrow pit operators whose economy is dependent upon that source of income. At the present time the material is being sold for the appraised sum of $0.50 per cubic yard. [The District] is not aware of any objections to that price on the part of prospective purchasers.

Market Requirements and Potential for Productive Use

220. A contracted study (Lone Star Industries, Inc. 1980) examined market requirements for Craney Island material. The study identified possible offsite productive uses of the material and associated constraints. The following paragraphs summarize the findings of this study.

Market area

221. A primary market for material removed from Craney Island (assuming truck transport) is considered to encompass an area within approximately a 10-mile radius. Within the vicinity of the primary market, there are now 24 authorized borrow pits, 20 of which are commercially operated. The volume of material produced from these existing sources will likely decrease in future years.

222. The estimated market requirements for coarse-grained material for various uses within the general vicinity of South Hampton Roads and within the primary market area are shown in Table 11. In general, demand for fill material in the area will decrease in the mid-1990's. Potential for productive use of material from Craney Island is described in the following subparagraphs.

Potential for use in construction

223. The principal use of fill material in the market area is for highway and road construction, comprising approximately 70 percent of total fill usage. The coarse-grained material available for use at Craney Island generally conforms to lower grade specifications for select fill as set by the Virginia Department of Highways. This material should be acceptable for use as fill in both public and private applications. Dewatered fine-grained material does not meet specifications for select fill. As shown in Table 11, the demand for such usage will decrease in the mid-1980's due to projected completion of major road construction projects.

Potential use as sanitary landfill cover

224. Only four large landfill operations were identified in the

Table 11

Estimated Market Requirements for Coarse-Grained Fill Material in South Hampton Roads (SHR) and Craney Island's Primary Market (PM)

	Market Requirements - 10^3 cu yd*							
	Highway and Road Construction		Cover for Sanitary Landfill		Other General Uses		Total	
Year	SHR	PM	SHR	PM	SHR	PM	SHR	PM
1979	2600	1600	475	--	425	150	3500	1750
1980	2300	1300	500	--	350	125	3150	1425
1981	3800**	2700**	510	--	375	135	4685**	2835**
1982	3700**	2700**	520	--	475	160	4695**	2860**
1983	2100	1100	530	--	500	170	3130	1270
1984	1900	1000	540	--	510	170	2950	1170
1985	1800	900	550	--	520	175	2870	1075
1986	1600	800	560	--	530	175	2690	975
1987	1600	750	570	--	540	180	2710	930
1988	1500	700	580	--	550	180	2630	880
1989	1500	675	590	--	560	185	2650	860
1990	1400	650	600	--	570	185	2570	835
1991	1400	650	610	--	580	190	2590	840
1992	1400	650	620	--	590	190	2610	840
1993	1400	650	630	--	600	195	2630	845
1994	1400	650	640	--	610	195	2650	845
1995	1400	650	650	--	620	200	2670	850

* Taken from report by Lone Star Industries (1980).

** Includes 1500 cu yd in 1981 and 1982 for I-664 bridge-tunnel islands.

market area. Closing of two of these is planned in the near future, and the remaining sites either operate onsite borrow pits or use trenching techniques for covering the waste. Therefore, the potential use of material from Craney Island for this purpose will probably not occur.

Potential use as random fill

225. Dewatered fine-grained material available at Craney Island could conceivably be used for some random landfill purposes. However, in general, the dewatered fine-grained material is not suitable for most landfill purposes, and would only have limited marketability as low-grade fill material.

Potential use for agricultural purposes

226. Analysis of a sample of fine-grained material by the Virginia Truck and Ornamentals Research station indicated a salt concentration greater than 4000 ppm. This renders the material unsuitable for use in agricultural land enhancement activities.

Dredged Material Reclamation

Coarse-grained material

227. Reclamation of coarse-grained dredged material from areas coinciding with traditional points of inflow will continue in future years on more or less the same volume basis as at the present time. Techniques now used to reclaim this material seem to be best suited for this particular site. The areas over which suitable coarse-grained materials are located are relatively small in comparison with the overall size of the disposal area. Loading of small quantities by dragline or front-end loader directly into trucks for transport is the most cost-effective approach.

228. Use of scrapers to move large quantities to rehandling points or directly to areas of dike upgrading may be desirable. No economic incentive now exists for large-scale removal equipment to be used (i.e. conveyor systems) for the coarse-grained deposits.

229. As the retaining dikes and interior dikes are upgraded, the

onsite requirements for coarse-grained material will increase. It may therefore be assumed that a majority of accumulated coarse-grained material will be productively utilized in dike upgrading and maintenance activities.

Fine-grained material

230. A preliminary assessment (Palermo 1978) of the potential for large-scale removal of fine-grained material from Craney Island identified significant technical constraints. The fine-grained material extends over the major portion of the disposal area, and water contents of the dredged material deposit remain near the liquid limit. Significant dewatering of this deposit would be required before any removal could be seriously considered (except removal adjacent to dikes for upgrading purposes).

231. Completion of subcontainments would allow easier management of surface water and subsequent dewatering (see discussion in Part VI). However, technical and economic constraints on movement of large volumes from the site interior may likely outweigh any benefits in storage volume gained. Based on the technical considerations and the limited market as discussed previously, reclamation of fine-grained material for use offsite is not considered feasible at this time.

PART VIII: CONSTRUCTION REQUIREMENTS

232. This part of the report describes construction activities required for implementation of the three-subcontainment design described in previous parts. Descriptions are given in general terms of recommended construction methods, equipment, materials, and sequencing.

233. Completion and upgrading of interior dikes and upgrading of main retaining dikes to el +30 ft are the major construction requirements. Since construction must proceed as disposal operations are in progress, the sequencing of construction becomes an important consideration. Description of dike construction to date is given in Part II.

234. Only general recommendations regarding construction techniques are possible since detailed data regarding crust thickness, rates of crust formation, equipment production rates, etc., are not available at this time. Further, the construction and upgrading of both the main retaining and interior dikes have evolved largely by trial. The final selection of construction technique based on field performance will also be required for future construction.

Interior Dikes

235. The storage capacity benefits to be derived through evaporative dewatering (see Parts V and VI) are dependent upon completion of the interior dike sections. An evaluation of techniques for completing these dikes (Haliburton and Hayes 1980) was made as part of the overall evaluation of dewatering feasiblity. Discussion regarding completion of interior dikes is largely based on this evaluation.

236. Approximately 8500 lin ft of interior dikes have been constructed to date. At the present rate, interior dikes are now progressing at less than 1000 lin ft/year (based on comparison of 1975 and 1980 surveys). However, with an intensified effort the interior dikes could be advanced 100 ft/week using available equipment.* More than

* Personal communication, Mr. Tom Lawless, Navigation Branch, Norfolk District.

11,000 lin ft of interior dike must be completed. Therefore, present construction techniques must be intensified to ensure timely completion. Dike construction is now proceeding at a fairly slow pace using discarded timbers, piling, and other debris placed on the dredged material surface for reinforcement of a semidisplacement dike section. Material used in dike construction is primarily clean sand deposited near dredge pipe locations on the east site perimeter. The material is loaded by crane, truck-hauled to the west end of the dike, dumped, and shaped by dozers. A fairly wide dike section has been constructed for both interior dikes, and the relatively slow rate of dike advancement has minimized the amount of dredged material displacement at the working face. For all practical purposes, dikes have been advanced at a rate consistent with the availability of timbers and other reinforcement materials, available sand from disposal operations, and available funding for contract construction.

237. However, to effectively compartmentalize the site, the remaining portions of the needed dike length will need to be constructed in a fairly rapid manner. Further, as the dike progresses westward, foundation conditions will become progressively poorer, as less and less surface crust is available. Also, ponded water will remain on the dredged material adjacent to the west dike due to ongoing disposal operations.

238. As discussed in Part I, alternatives available for rapid dike construction include:

- a. Continuation of the procedure currently used for dike advancement, except at a faster rate.
- b. Construction of a full displacement section, the historical method used for dike construction on extremely soft material.
- c. Use of a geotechnical fabric-reinforced floating dike section.

239. Dike construction procedures used to date have obviously been successful. However, the success of the semidisplacement construction results from the timber, piling, and other reinforcement placed transverse to the realignment at the base of the dike. Thus, feasibility

of increasing rate of dike construction by this method is dependent on the availability of no-cost timber, piling, and other such materials, which are brought to the site for disposition.

240. Use of a full-displacement section technique to complete the interior dikes is certainly technically feasible. However, it should be noted that the displacement sections would have to be constructed across an area which recent field exploration has found to contain approximately 24 ft of fine-grained dredged material at or near the liquid limit, underlain by extremely soft highly plastic marine clays. Based on currently accepted practice for displacement section construction, it is estimated that a minimum of three volumes of material below grade would be required to obtain one volume of material above grade and, considering the low strength and great depth of poor foundation (dredged) material, the displacement ratio could easily become five volumes below grade for one volume above grade. Thus, completion of the dikes by displacement methodology would require a considerable volume of sand and existing dewatered material available onsite. Use of such material for displacement section completion of the interior dikes may cause a scarcity of material available to complete raising the perimeter dikes to el +30 ft and, thus, require either a delay in the perimeter dike-raising program or additional dike-raising material, perhaps obtained from offsite by hydraulic sand dredging or truck haul. Thus, in summary, while displacement section completion of the interior dikes is technically feasible, the operational practicality of such a scheme, in conjunction with other disposal site dike-raising activities, is questionable. Also, displacement section construction is usually not cost-effective.

241. One alternative for completing the perimeter dikes appears to be use of geotechnical fabric-reinforced dike construction. In such a construction scheme, the geotechnical fabric would serve essentially the same purpose as the timber and piling reinforcement currently used. Proper placement of fabric would allow construction of a "floating" section with essentially minimal bearing displacement and positive assurance of constructability, eliminating possible horizontal splitting

or foundation bearing/embankment rotational failures. Such a dike was constructed as part of a cooperative U. S. Army Engineer District, Mobile-WES project (Haliburton, Fowler, and Langan 1980) to a height of 8 ft on a 40-ft-thick deposit of material with cohesion of 50-100 psf. Minimal bearing displacements occurred and less than 1 ft of consolidation settlement was observed. This section had a benefit-cost ratio of approximately 3, compared to conventional displacement construction procedures. Fowler (1981) discribes procedures for analysis, design, and construction of such fabric-reinforced dikes. Final decision regarding the use of fabric-reinforced construction technique should be based on field trial.

Main Retaining Dikes

242. Foundation analysis (Norfolk District 1971) has indicated that construction of main retaining dikes to el +30 ft is possible with a total bench distance of approximately 1000 ft. The ideal dike section is shown in Figure 3. The recommended operational procedures (see Part IX) call for locating all inflow points along the eastern dike. As shown in Figure 30, the natural slope of the fine-grained material is approximately 5 ft in 10,000 ft. This requires the overall dike construction to be tailored to contain this slope. The east and west dikes would therefore be constructed to approximate crown elevation of +32.5 and +27.5 ft, respectively, while the north and south dikes would require a sloping crown elevation from east to west. In general, a stepped or benched dike construction technique (see conceptual section in Figure 20a) using material adjacent to the dike alignment is recommended for upgrading the main retaining dikes, supplemented as required by truck-hauled coarse-grained material and use of fabric-reinforced sections in extremely wet areas.

East dike

243. The majority of all accumulated coarse-grained material is now located along the east dike, providing a convenient source for construction material. As described in Part II, few problems have been

encountered in progressively raising this dike due to the firm foundation afforded by the coarse-grained material. The section is now benched approximately 250 ft. In order to reach a required bench distance of 1000 ft, the new alignment will be partially located on the fine-grained dredged material. However, the higher elevation along the eastern portion of the site allows considerable periods of drying. The incremental construction method used successfully for the intermediate north dike section should prove satisfactory for the full 1000-ft bench section along the east dike. Draglines operating on mats pulling up adjacent material should be satisfactory. Additional coarse-grained material can be truck-hauled to points at a greater distance from areas of accumulated coarse material.

North dike

244. At the present time, an extensive area of accumulated coarse-grained material exists in the NE and NW corners of the disposal area. Construction of a 1000-ft bench section within these corner areas could easily be accomplished by dragline. However, the remainder of the north dike section must be constructed on fine-grained material. This section can be constructed using methods previously used in constructing the intermediate bench section.

West dike

245. The continuously wet condition of the western portion of the disposal area has prevented benching of this dike. However, completion of interior dikes as described previously will allow drying and crust formation during inactive cycles. Flotation draglines and/or conventional draglines operating on mats could then be used to pull up adjacent material to form a base section. In areas where drying has not progressed sufficiently, the fabric-reinforced construction technique could be used. Construction of new weirs (see discussion in Part IV) should be concurrent with construction of benched sections of the west dike.

Construction Sequencing

246. Since completion of interior dikes and upgrading of main

retaining dikes must be accomplished as disposal operations are in progress, the sequencing of both disposal and construction becomes an important consideration. In general, flow due to active disposal operations must not interfere with ongoing construction. Completion of interior dikes will serve to isolate flow to one of the three subcontainments, allowing construction activity to proceed in the two remaining.

247. The recommended overall staging of construction for completion of interior dikes and bench sections of main retaining dikes is shown in Figure 79. The indicated sequencing generally corresponds to annual stages of construction (e.g. interior dikes must be completed during Stages 1-3 before the west dike can be completed during Stage 4). Individual stages of construction/operation are discussed in Part I and are shown in Figures 4-9.

248. Stability considerations for the overall retaining dike dictate that the existing 250-ft bench will allow an average elevation of +17.0 ft within the disposal area interior. The present mode of operation should continue for approximately 3 years to achieve this average elevation. This would take maximum advantage of the present dike alignment and correspondingly greater surface area available for disposal. During this period, efforts to complete the interior dikes (Stages 1-3) must be expedited to ensure their timely completion.

Maintenance Activities

249. Completion of interior dikes will add approximately 11,000 lin ft of dike to the system now being maintained. Also, future completion of benched sections for the main retaining dikes will further increase maintenance requirements due to wider and higher sections, need for new roadways, etc.

250. Currently, the maintenance equipment inventory at Craney Island consists of the following:

Item	Quantity
10-cu-yd dump truck	3
6-cu-yd dump truck	3

(Continued)

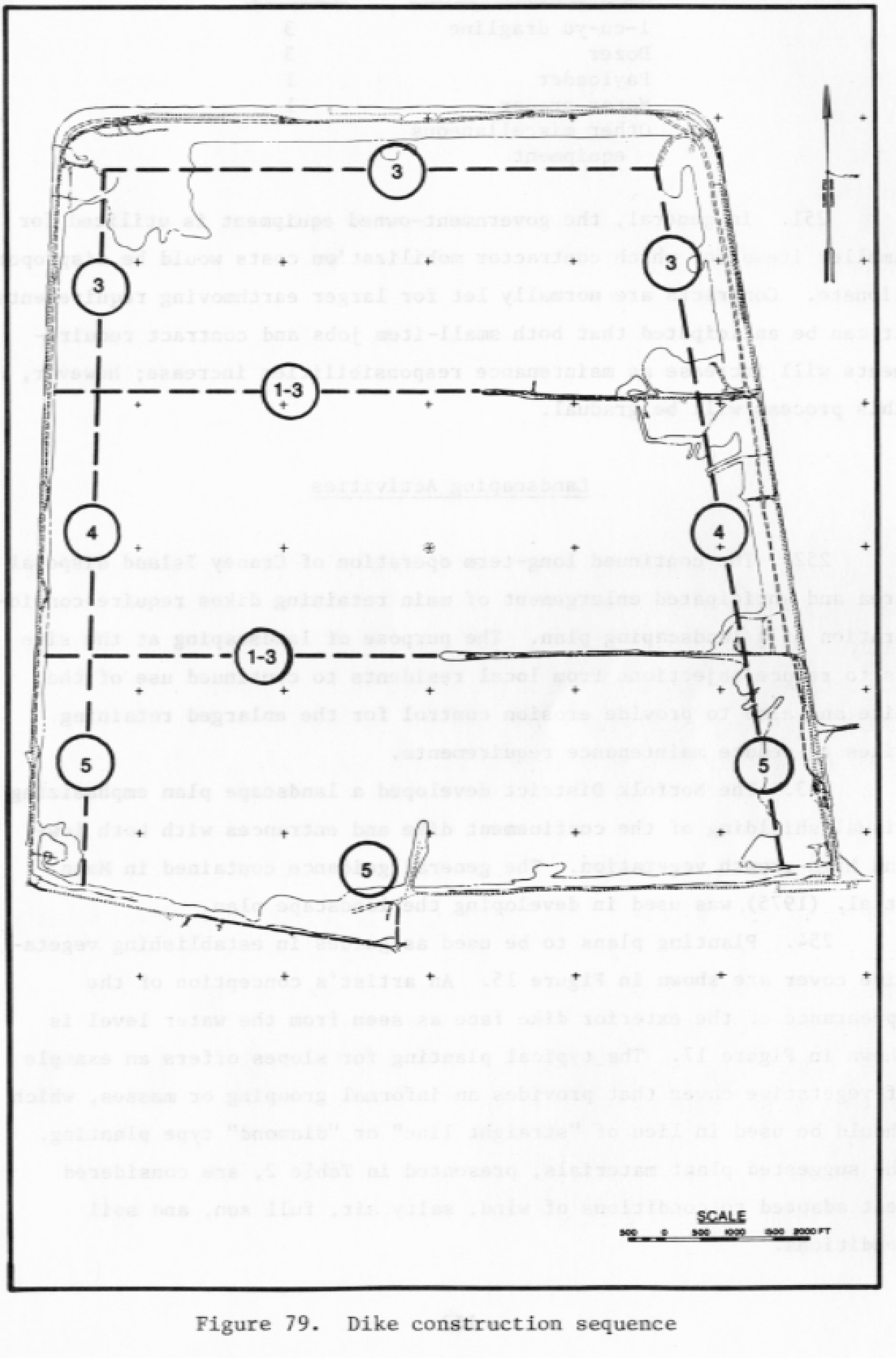

Figure 79. Dike construction sequence

Item	Quantity
1-cu-yd dragline	3
Dozer	3
Payloader	1
Motor grader	1
Other miscellaneous equipment	

251. In general, the government-owned equipment is utilized for smaller items for which contractor mobilization costs would be disproportionate. Contracts are normally let for larger earthmoving requirements. It can be anticipated that both small-item jobs and contract requirements will increase as maintenance responsibilities increase; however, this process will be gradual.

Landscaping Activities

252. The continued long-term operation of Craney Island disposal area and anticipated enlargement of main retaining dikes require consideration of a landscaping plan. The purpose of landscaping at the site is to reduce objections from local residents to continued use of the site and also to provide erosion control for the enlarged retaining dikes to reduce maintenance requirements.

253. The Norfolk District developed a landscape plan emphasizing visual shielding of the confinement dike and entrances with both low- and high-growth vegetation. The general guidance contained in Mann et al. (1975) was used in developing the landscape plan.

254. Planting plans to be used as guides in establishing vegetative cover are shown in Figure 15. An artist's conception of the appearance of the exterior dike face as seen from the water level is shown in Figure 17. The typical planting for slopes offers an example of vegetative cover that provides an informal grouping or masses, which should be used in lieu of "straight line" or "diamond" type planting. The suggested plant materials, presented in Table 2, are considered best adapted to conditions of wind, salty air, full sun, and soil conditions.

255. It is suggested that test plantings be installed between the dates of 15 October and 1 April, and that the sizes of plantings obtained from nurseries be on the small side. After a period of 1-2 years, performance of test plantings may be used as a guide for subsequent landscaping activities.

PART IX: OPERATION AND MANAGEMENT

256. This part of the report describes in general terms the operational procedures and management activities necessary to implement the overall management plan. The discussion assumes the acceptance and implementation of recommendations to complete interior dikes, forming three subcontainments.

Interim Operation

257. If completion of interior dikes is implemented, an interim mode of operation will be required until that construction phase is complete. This will require only minor considerations in location of inflow pipes and weir operation with relation to ongoing construction. Interior dikes may be advanced for a considerable distance (to perhaps 1000 ft from the west dike) before any interference from or effects on the disposal operation become apparent. But, as the working face nears the west dike, location of inflow pipes and operation of a weir structure on opposite sides of the advancing interior dike (see inflow location 1 in Figure 80) should be avoided due to potential scour problems.

258. Since completion of interior dikes will not have allowed drying on the western side, maintenance of the retaining dike and ponding conditions will be unchanged.

Disposal Sequencing

259. Once interior dikes are completed, a triennial schedule for disposal, rotating between the three subcontainments, can be initiated. Use of alternate subcontainments would be generally phased on an annual basis. The time for alternating would probably best be scheduled to coincide with fiscal years. A "switchover" at the fiscal year would allow maximum utilization of the dry period (April to October) for dewatering the inactive subcontainment next in line for the active cycle. However, the schedule must retain flexibility to allow for dredging

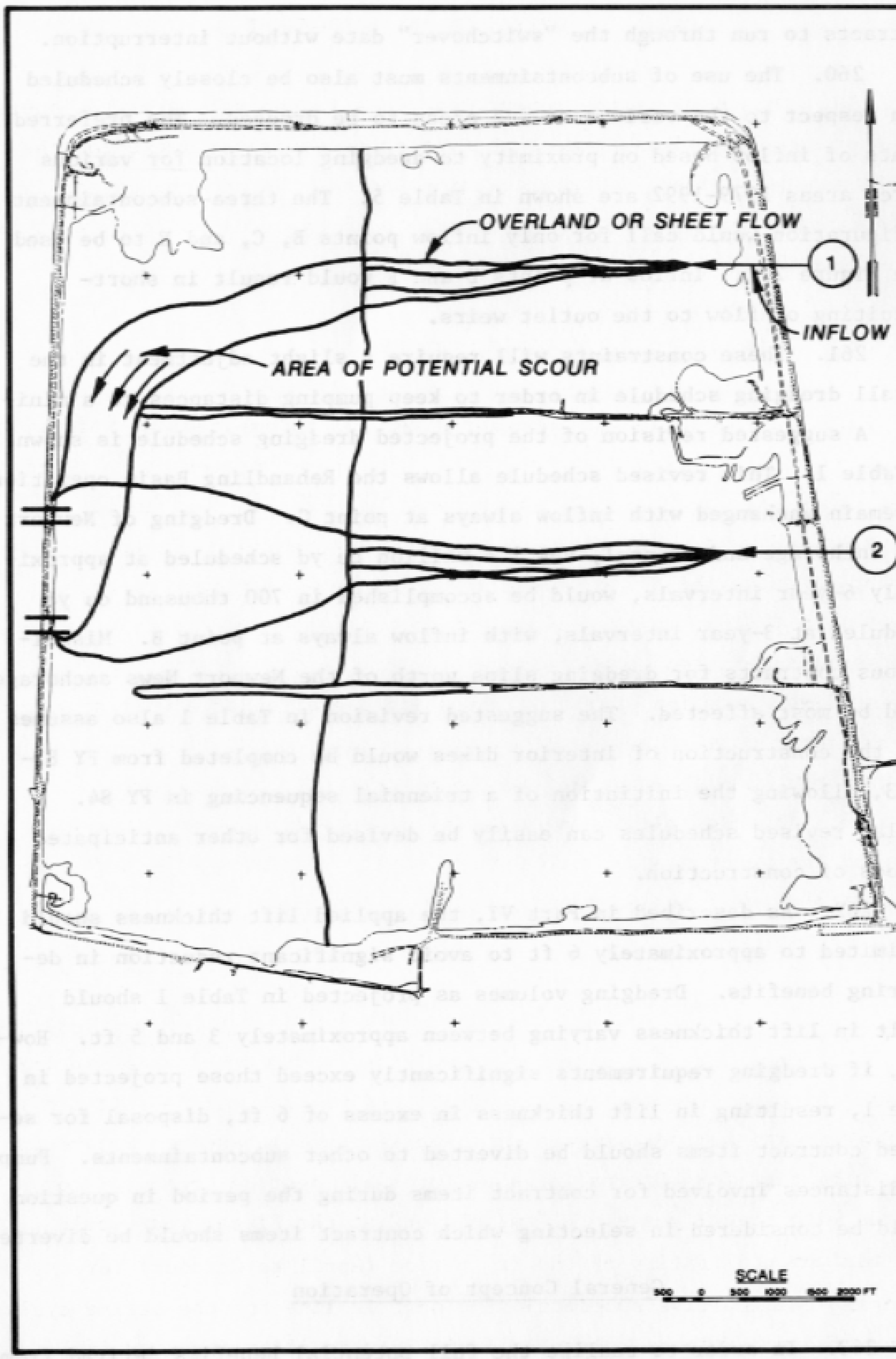

Figure 80. Points of inflow and weirs for interim operation

contracts to run through the "switchover" date without interruption.

260. The use of subcontainments must also be closely scheduled with respect to the various source areas to be dredged. The preferred points of inflow based on proximity to dredging location for various source areas 1979-1992 are shown in Table 5. The three-subcontainment configuration would call for only inflow points B, C, and E to be used (see Figure 27). Inflow at points D and F would result in short-circuiting of flow to the outlet weirs.

261. These constraints will require a slight adjustment in the overall dredging schedule in order to keep pumping distances to a minimum. A suggested revision of the projected dredging schedule is shown in Table 1. This revised schedule allows the Rehandling Basin operation to remain unchanged with inflow always at point C. Dredging of Newport News anchorage and channel, now 1.4 million cu yd scheduled at approximately 6-year intervals, would be accomplished in 700 thousand cu yd scheduled at 3-year intervals, with inflow always at point B. Miscellaneous contracts for dredging slips north of the Newport News anchorage would be most affected. The suggested revision in Table 1 also assumes that the construction of interior dikes would be completed from FY 81-FY 83, allowing the initiation of a triennial sequencing in FY 84. Similar revised schedules can easily be devised for other anticipated periods of construction.

262. As described in Part VI, the applied lift thickness should be limited to approximately 6 ft to avoid significant reduction in dewatering benefits. Dredging volumes as projected in Table 1 should result in lift thickness varying between approximately 3 and 5 ft. However, if dredging requirements significantly exceed those projected in Table 1, resulting in lift thickness in excess of 6 ft, disposal for selected contract items should be diverted to other subcontainments. Pumping distances involved for contract items during the period in question should be considered in selecting which contract items should be diverted.

General Concept of Operation

263. In order to realize the full potential benefits derived from

subdivision and dewatering, the operation of the three-subcontainment configuration must accomplish three main objectives:

- a. Maintain acceptable water quality for the active subcontainment.
- b. Remove ponded water and maintain a dry condition in the inactive subcontainments.
- c. Accommodate the overall disposal requirements.

264. These objectives require effective management of surface waters for both active and inactive subcontainments. Figure 10 illustrates the alternating sequence of disposal, first-year dewatering, and second-year dewatering. Management of surface water is described in the following paragraphs. Activities related to completion of dikes and dredged material dewatering are described in Parts VI and VIII, respectively.

Preparation of Subcontainments for Disposal

265. Prior to initiation of an active disposal phase for any respective subcontainment, the following management actions should be completed. During the 2-year inactive phase, dikes will required maintenance and upgrading using primarily dried dredged material taken from areas adjacent to the dike alignment and truck-hauled coarse materials as required. Considering the size of the Craney Island disposal area, this process will likely be on a continuous basis.

266. Vegetation within the disposal area may be more extensive if the dredged material surface is kept in a dried condition. Any growth which might induce short-circuiting of flow should be removed by harvesting or burning prior to disposal operations.

267. Weir boarding should be estimated for the active cycle based on anticipated lift thickness plus ponding depth. Boarding should be placed to the elevation required for minimum ponding prior to initiation of disposal. Weir structures should be thoroughly checked for any required maintenance.

Surface Water Management During Disposal

268. During periods of active disposal operations, ponded water must be maintained to ensure adequate effluent water quality. The rule curve for ponding required at the west dike for various inflow rates (see Figure 11) should be used as a guide. A minimum ponding depth of 2 ft is recommended, even though lesser ponding depths may result in sufficient ponded surface areas for settling at low flows. The 2-ft minimum will reduce any tendency to short-circuit and will offset any local variation in surface topography, allowing flow to reach both weirs (once the bench section and new weirs are in place as in Figure 63).

269. Required ponding depths as indicated by Figure 1 are designed to produce required surface areas for sedimentation, considering a surface slope of 5 ft in 10,000 ft. Local depressions near the dikes caused by trenching or erosion should not be considered in determining the ponding depth.

270. The weir boarding will require periodic adjustment as the dredged material surface rises, always maintaining suitable ponding depth. During periods of nondisposal, the pond should be slowly decanted as described in the following paragraphs to induce maximum drying.

Management Activities Following Disposal

271. The continuous inspection and management of subcontainments during inactive cycles will be required to prevent ponding of surface water. The weir crest elevation must be kept at levels allowing efficient release of runoff due to precipitation. The magnitude of runoff for a given storm event will likely increase as periphery and interior trenches form a more efficient surface drainage system. Also, the dredged material surface will settle continuously due to consolidation and drying. Once a surface crust forms on the material, erosion due to runoff will be minimized. Therefore, ponding is not required to maintain water quality of runoff water.

Monitoring Program

272. A monitoring program for the ongoing operation and management of the Craney Island disposal area is required to ensure that expected benefits are realized. The program should provide information regarding influent characterization, effluent suspended solids, rate of filling, etc., for active cycles; and rates of consolidation and desiccation for inactive cycles. These data can be used to update future projections of storage capacity and increase the accuracy of the projections.

Sampling and testing

273. The physical and engineering properties of sediments and dredged material used in evaluating water quality and storage capacity for various alternatives were based on limited samples and laboratory tests. This is particularly true for sediments which were sampled at one point in time and for which little or no information exists regarding variation of properties with respect to time and spatial distribution.

274. Sediment sampling. Additional sampling of sediments should be accomplished periodically to verify the relationships used in this management plan regarding variation of properties with space and time. Sampling procedures as described in Part III were found to be satisfactory, producing samples representative of in situ channel conditions.

275. Dredged material sampling. Dredged material samples were taken from only a small area in the western portion of the disposal area due to operational constraints. Upon completion of subcontainments and subsequent drying, an opportunity will be presented for additional sampling in areas not now accessible. This sampling would be best accomplished in conjunction with placement of piezometers and settlement plates as described in the following paragraphs. Additional sampling of dredged material crust should also be accomplished to better establish desiccation and crust formation rates.

276. Laboratory testing. Additional laboratory tests should be performed to include characterization and physical properties tests, sedimentation, and consolidation tests.

Monitoring activities

277. Suspended solids monitoring. Samples of both inflow and effluent should be taken on a routine basis for determination of solids concentration. Inflow samples should be taken for various operating conditions (dredge sizes, pumping distances, sources areas, etc.) to develop a satisfactory data base for both government- and contractor-owned equipment which normally disposes into Craney Island. Inflow samples should be taken daily for each inflow until reliable values for inflow concentration are established. Since disposal operations are essentially continuous year-round during active cycles, a weekly weir effluent sample should prove satisfactory.

278. Storage capacity monitoring. Two methods should be employed to monitor rates of filling during active cycles and rates of subsidence during inactive cycles: (a) topographic surveys and (b) settlement plates. Topographic surveys should be obtained at yearly intervals, once subcontainments are completed. These data allow direct verification of estimated projections of storage capacity over long time periods. In addition, settlement plates placed in each subcontainment will allow monitoring of filling rates and consolidation rates based on periodic survey at discrete points. Settlement plates would be most easily installed once a dry condition is attained within the respective subcontainments. At the same time, piezometers should be installed to determine groundwater table conditions within the disposal area. Additional samples of dredged material could also be acquired at this time. Suggested locations for settlement plates/piezometers are shown in Figure 81. Details of installation are available in EM 1110-2-1908 (OCE 1971).

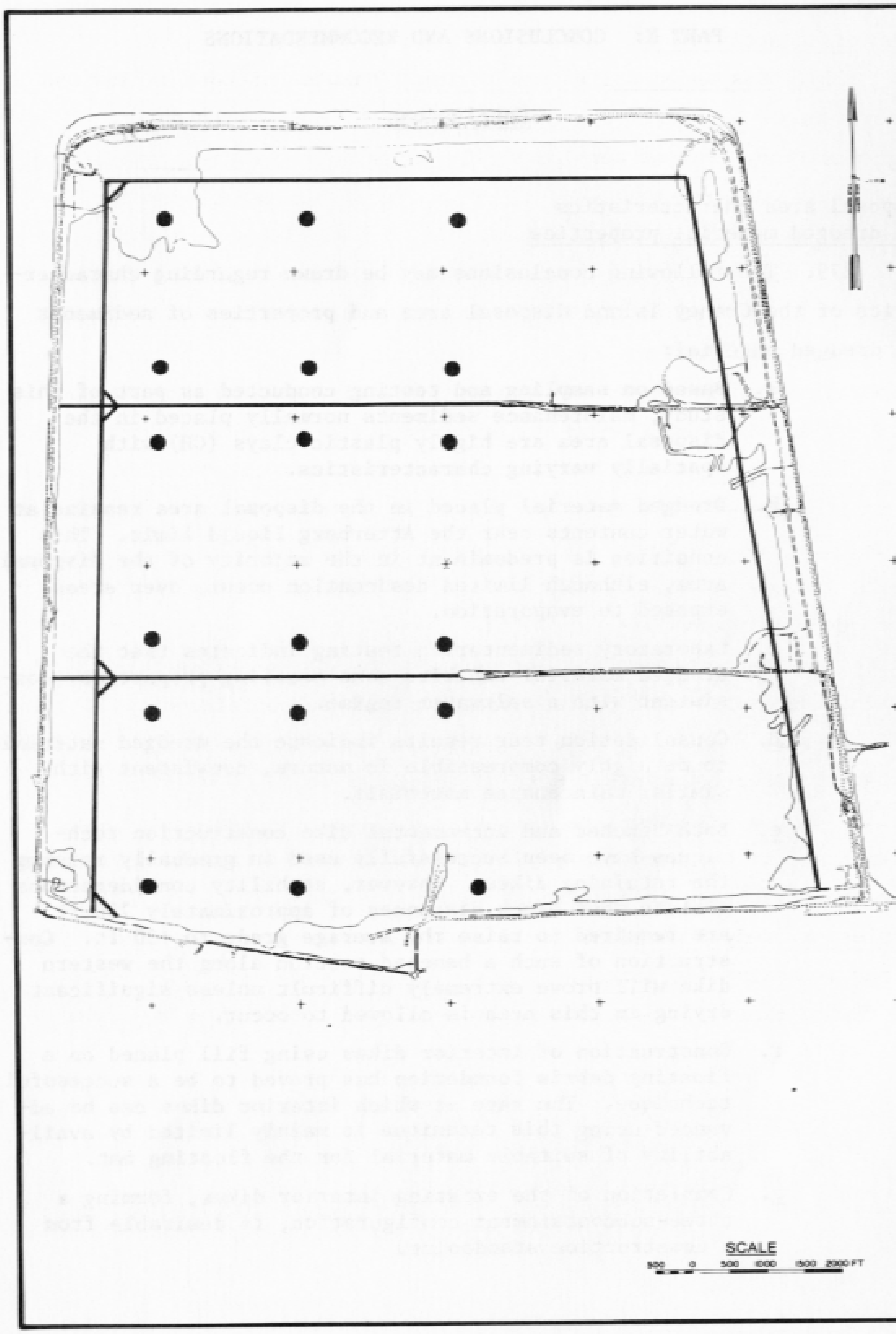

Figure 81. Suggested location of settlement plates and piezometers

PART X: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Disposal area characteristics and dredged material properties

279. The following conclusions may be drawn regarding characteristics of the Craney Island disposal area and properties of sediments and dredged material:

- a. Based on sampling and testing conducted as part of this study, maintenance sediments normally placed in the disposal area are highly plastic clays (CH) with spatially varying characteristics.
- b. Dredged material placed in the disposal area remains at water contents near the Atterberg liquid limit. This condition is predominant in the majority of the disposal area, although limited desiccation occurs over areas exposed to evaporation.
- c. Laboratory sedimentation testing indicates that the dredged material exhibits zone settling properties, consistent with a saltwater regime.
- d. Consolidation test results indicate the dredged material to be highly compressible in nature, consistent with similar maintenance materials.
- e. Both benched and incremental dike construction techniques have been successfully used in gradually raising the retaining dikes. However, stability considerations dictate that bench distances of approximately 750 ft are required to raise the average grade to +30 ft. Construction of such a benched section along the western dike will prove extremely difficult unless significant drying in this area is allowed to occur.
- f. Construction of interior dikes using fill placed on a floating debris foundation has proved to be a successful technique. The rate at which interior dikes can be advanced using this technique is mainly limited by availability of suitable material for the floating mat.
- g. Completion of the existing interior dikes, forming a three-subcontainment configuration, is desirable from a construction standpoint.

Water quality

280. The following conclusions may be drawn regarding the water quality of effluent:

a. Water quality of effluent has remained within acceptable levels due to the large area now available for sedimentation.

b. Limited ponding depths due to dike stability considerations have not adversely affected water quality due to the large size of the disposal area.

c. Completion of interior dikes and usage of alternating subcontainments will reduce areas available for sedimentation and will require increased ponding depths to ensure adequate sedimentation.

d. Use of a four- or five-subcontainment configuration will require impractical ponding conditions at maximum anticipated flow conditions to maintain acceptable water quality. Use of a six-subcontainment configuration will not provide sufficient surface area to maintain water quality.

e. Use of a three-subcontainment configuration will provide sufficient ponded surface areas with a 3-ft ponded depth maintained at the weirs for high flow conditions and with a 2-ft ponded depth for average flow conditions.

f. An effective weir length of 150 ft for the three-subcontainment configuration is required to maintain acceptable water quality over the anticipated range of flow conditions.

Storage capacity

281. The following conclusions may be drawn regarding storage capacity:

a. The disposal area has provided considerably more storage capacity than the 100 million cu yd initially predicted due to consolidation of underlying layers of dredged material, limited consolidation of foundation soils, and limited desiccation due to natural evaporative processes.

b. Only limited desiccation has occurred due to the almost continuous usage of the area for disposal. This is particularly true for the western portion of the disposal area where ponded conditions are maintained for long time periods.

c. Model projections indicate a disposal area life of approximately 19 years under the present mode of operation (until an average elevation of +30 ft is reached).

d. Model projections indicate that the four-subcontainment configuration is optimum from a storage capacity standpoint. However, benefits derived from utilizing partially completed interior dikes for the three-subcontainment configuration far outweigh any additional storage capacity benefits of the four-subcontainment configuration.

e. Completion of interior dikes and formation of subcontainments will expose larger surface areas to natural evaporative forces. Assuming no increase in present desiccation rates, disposal area life would be increased approximately 12 percent for the three-subcontainment configuration.

f. Implementation of an active dewatering program will increase desiccation, significantly adding to storage capacity. Model projections indicate a disposal area life of approximately 36 years using a 100 percent efficient surface drainage system (until an average surface elevation of +30 ft is reached), representing practically double that estimated for the present mode of operation. Actual benefits will probably be less due to inefficiencies of the drainage system.

Dewatering benefits

282. The following conclusions may be drawn regarding potential dewatering benefits:

a. Evaporative forces will produce sufficient dredged material drying to fully dewater anticipated lift thicknesses for the three-subcontainment configuration. Therefore, a surface drainage system installed to efficiently remove precipitation is the most cost-effective and implementable dewatering approach. However, lift thickness should be limited to 6 ft to avoid significant reduction of dewatering benefits.

b. Enough dewatered fine-grained dredged material would be produced by dewatering activities to allow extremely cost-effective future perimeter and interior dike-raising, with a considerable additional volume of dewatered dredged material available for removal and other productive use, if feasible and/or desirable.

c. The unit cost of creating disposal volume by evaporative dewatering is favorable when compared to costs of creating storage volume by construction of an adjacent disposal area, or of continuing to raise perimeter dikes.

Potential marketing and
<u>productive use of dredged material</u>

283. The following conclusions may be drawn regarding potential marketing and productive use of dredged material from the Craney Island disposal area:

- a. Reclamation of coarse-grained material accumulated at points of inflow will continue in future years at about the present rate.
- b. The majority of the coarse-grained material will be utilized in onsite dike upgrading and maintenance activities, since the demand for this use will increase as overall dike sections become larger.
- c. Offsite demands for coarse-grained fill material within the primary market area (10-mile radius) will decrease in future years.
- d. Coarse-grained material at Craney Island conforms to lower grade specifications for select fill and should be acceptable for use in both public and private applications.
- e. Dewatered fine-grained material could conceivably be used as random fill. However, the material is not suitable for most fill applications and would only have limited marketability.
- f. Dewatered fine-grained material can be effectively used in dike-raising and maintenance. Such use is best accomplished by direct placement as periphery trenches are constructed and deepened to futher assist dewatering efforts.

Recommendations

284. The following recommendations are made regarding operation, management, and construction requirements for the Craney Island disposal area:

- a. The disposal area should be subdivided, forming three subcontainments, by completing the existing interior or spur dikes.
- b. While the interior dikes are under construction, the disposal area should be operated using essentially the present mode of operation as discussed in Part IX.
- c. Once closure of interior dikes is completed, a triennial sequence of disposal in each subcontainment should be

initiated, allowing for a 1-year active disposal cycle followed by a 2-year inactive cycle.

d. Inflows to the subcontainments should be limited to the eastern side of the containment area. The triennial sequencing should be scheduled as shown in Table 1 to allow use of the south containment for Rehandling Basin dredging and the north subcontainment for Newport News dredging. Slight adjustment of the long-range dredging schedule is recommended to better conform to annual rotation between the three subcontainments and to minimize any increases in required pumping distances.

e. Operation of the disposal area under the triennial sequence should be according to guidelines given in Part IX and Part I. These guidelines essentially call for maintenance of required pond during active disposal cycles and removal and prevention of ponded water during inactive cycles.

f. During inactive cycles, an aggressive program of surface trenching should be initiated as discussed in Part VI to more efficiently remove precipitation, thereby increasing effective desiccation rates and dewatering the fine-grained dredged material.

g. Construction of interior dikes should be accomplished either by accelerating the present method of construction or by using a fabric-reinforced dike section. Field tests of fabric-reinforced sections are recommended prior to final selection of construction method. Construction of interior dikes should be accomplished over approximately a 3-year period.

h. Construction of dike sections to grade of +30 ft at bench distances of 750 ft should be gradually accomplished as conditions allow, following closure of interior dikes. East, north, and south dikes can be raised using essentially the same techniques as previously used to achieve the present grade. The west dike must be raised following closure of interior dikes and drying within respective subcontainments. A combination of dragline construction, using adjacent dewatered dredged material, and fabric-reinforced sections as required is recommended for the west dike.

i. Design of the west dike should be such that a minimum 2-ft pond can be maintained for normal operating conditions throughout the active cycle and a 3-ft pond should be accommodated for shorter periods of high inflow.

j. In conjunction with completion of the west dike, a total of six new weir structures, each with an effective weir length of 75 ft, are recommended. The structures should be located in the west corners of each subcontainment as shown in Figure 63.

k. Periphery trenches should be constructed during inactive cycles to provide material for dike-raising and maintenance and to develop an effective surface drainage system. These trenches can best be constructed using amphibious draglines or conventional draglines operating on mats.

l. Interior trenching using amphibious Rotary Trenchers or similar equipment should be initiated following development of sufficient crust thickness to provide mobility for equipment. It is recommended that field trials be used as a basis for final selection of equipment for interior trenching.

m. A comprehensive sampling, testing, and monitoring program as discussed in Part IX should be developed to verify benefits attained and to form a basis for future projections of benefits or for changes in mode of operation and management. The program should include additional sediment and dredged material sampling, laboratory tests, installation of piezometers and settlement plates, and periodic topographic surveys.

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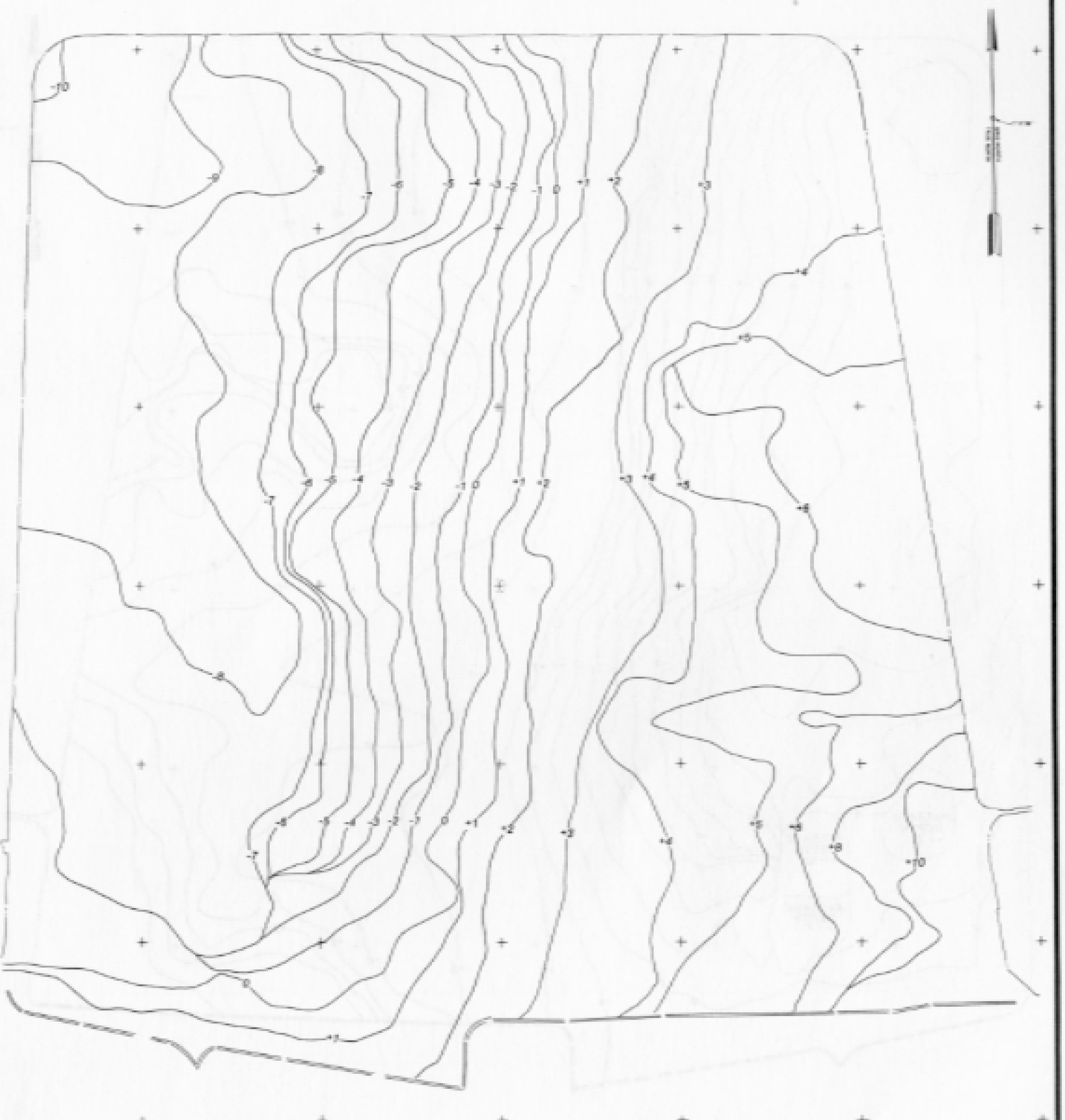
APPENDIX A: CONSOLIDATED RECORD OF MATERIAL DEPOSITED IN CRANEY ISLAND DISPOSAL AREA

This appendix presents descriptions, period of contract, cubic yards dredged (in-channel yardage), and pipeline size for each dredging contract for which dredged material was placed in the Craney Island disposal area. These data were used to determine ranges of possible inflows for the disposal area and for the filling simulation used in determining future storage capacity. (This appendix is reproduced on microfiche.)

APPENDIX B: DISPOSAL AREA TOPOGRAPHIC DATA

This appendix presents topographic data developed from surveys taken periodically during the period of active disposal operations at Craney Island (Plates B1-B6). The surveys were performed using a combination of land surface techniques, hydrographic techniques (from boats operating within the disposal area), and aerial techniques. Topographic information was used to obtain estimates of the average surface elevation at various times (see Figure 64) and to obtain information regarding the layering and slopes maintained by the dredged material (see Figure 30).



SOUNDINGS AND ELEVATIONS ARE IN FEET REFERRED TO CE MLW DATUM WHICH IS 1.50 FEET BELOW MSL.

——— CONTOUR ESTABLISHED BY SURVEY
- - - - - ESTIMATED CONTOUR

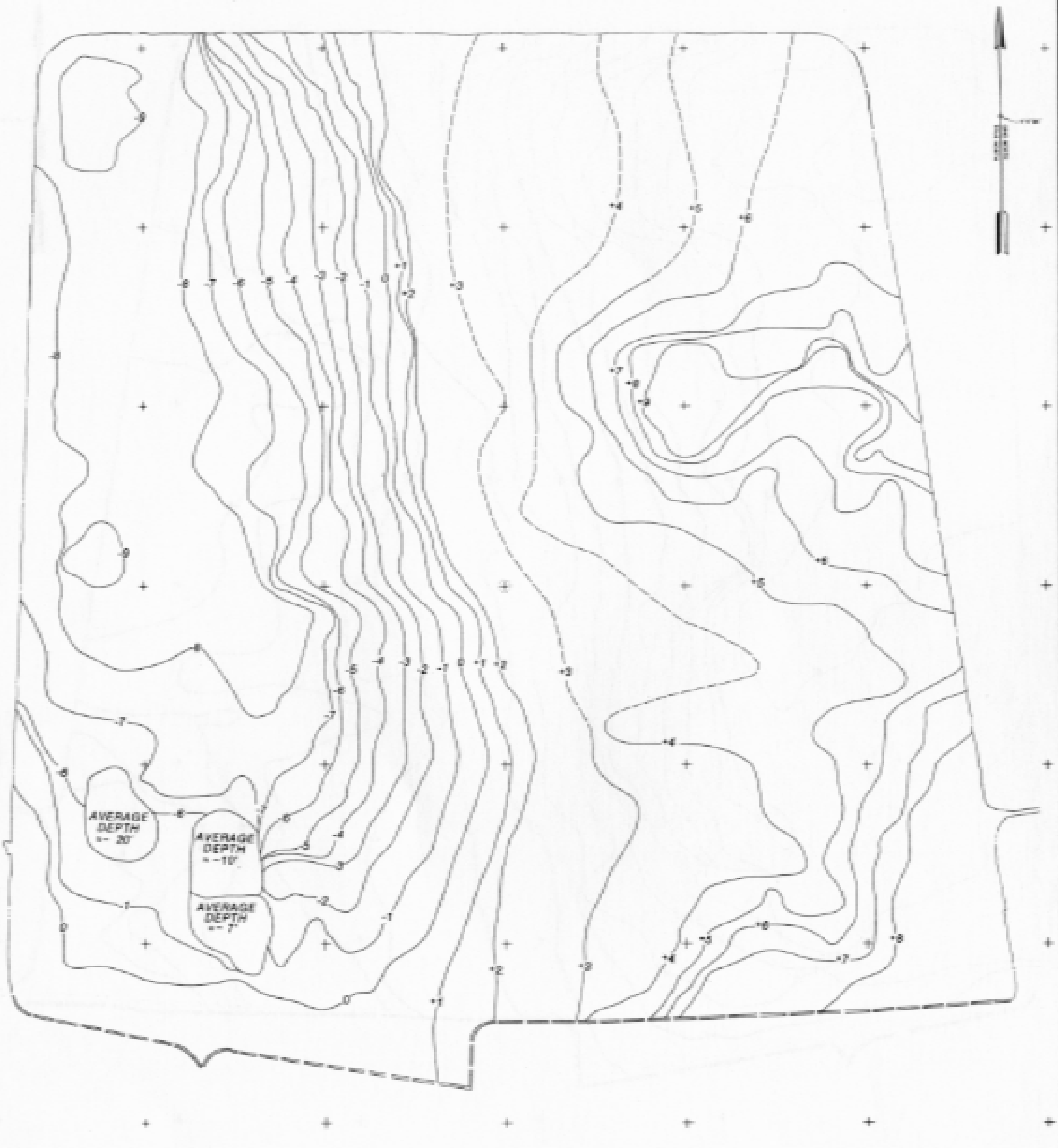
NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

SURVEY OF 1965

SCALE

500 0 500 1000 1500 2000 FT



NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

SURVEY OF 1966

SCALE

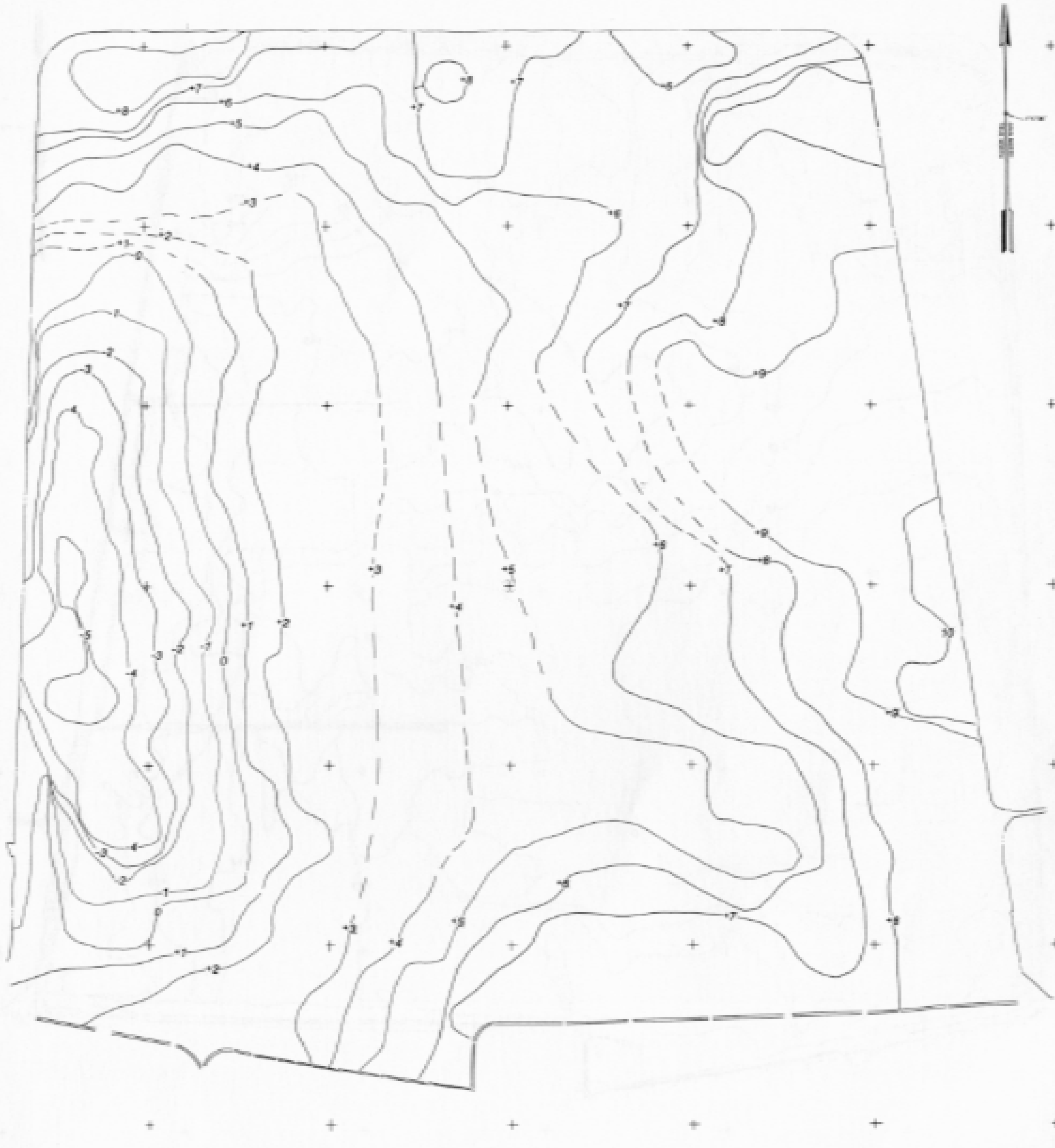
500 0 500 1000 1500 2000 FT

SOUNDINGS AND ELEVATIONS ARE IN FEET REFERRED TO CE MLW DATUM WHICH IS 1.50 FEET BELOW MSL.

——— CONTOUR ESTABLISHED BY SURVEY

- - - - - - ESTIMATED CONTOUR

PLATE B2



NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

SURVEY OF 1968

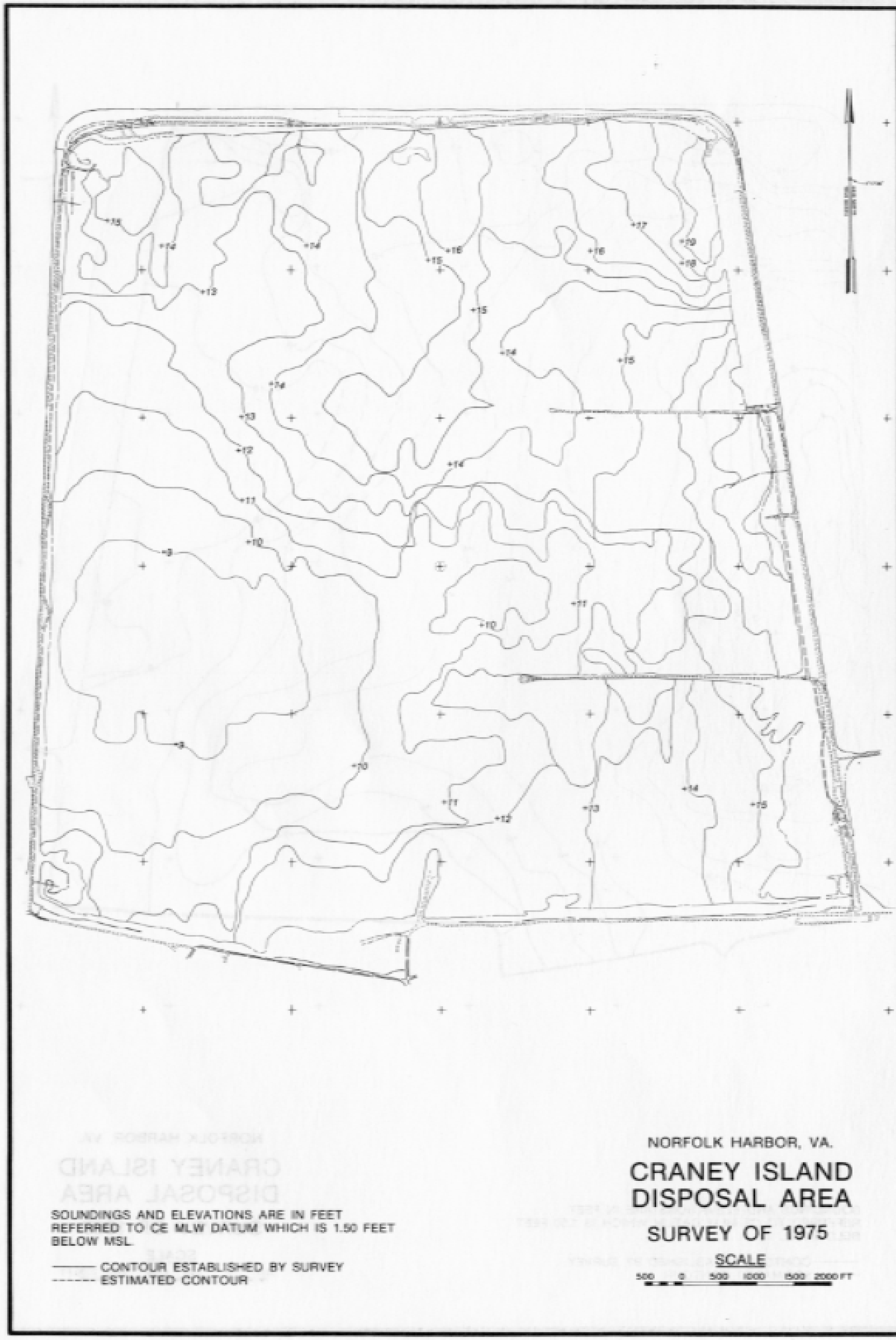
SCALE

500 0 500 1000 1500 2000 FT

SOUNDINGS AND ELEVATIONS ARE IN FEET REFERRED TO CE MLW DATUM WHICH IS 1.50 FEET BELOW MSL.

——— CONTOUR ESTABLISHED BY SURVEY

- - - - - ESTIMATED CONTOUR


+15
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+15
NORFOLK HARBOR, VA.
CRANEY ISLAND
DISPOSAL AREA
SURVEY OF 1975
SOUNDINGS AND ELEVATIONS ARE IN FEET
REFERRED TO CE MLW DATUM WHICH IS 1.50 FEET
BELOW MSL.
CONTOUR ESTABLISHED BY SURVEY
ESTIMATED CONTOUR
SCALE
500 0 500 1000 1500 2000 FT

PLATE B4

NORFOLK HARBOR, VA.

CRANEY ISLAND DISPOSAL AREA

SURVEY OF 1977

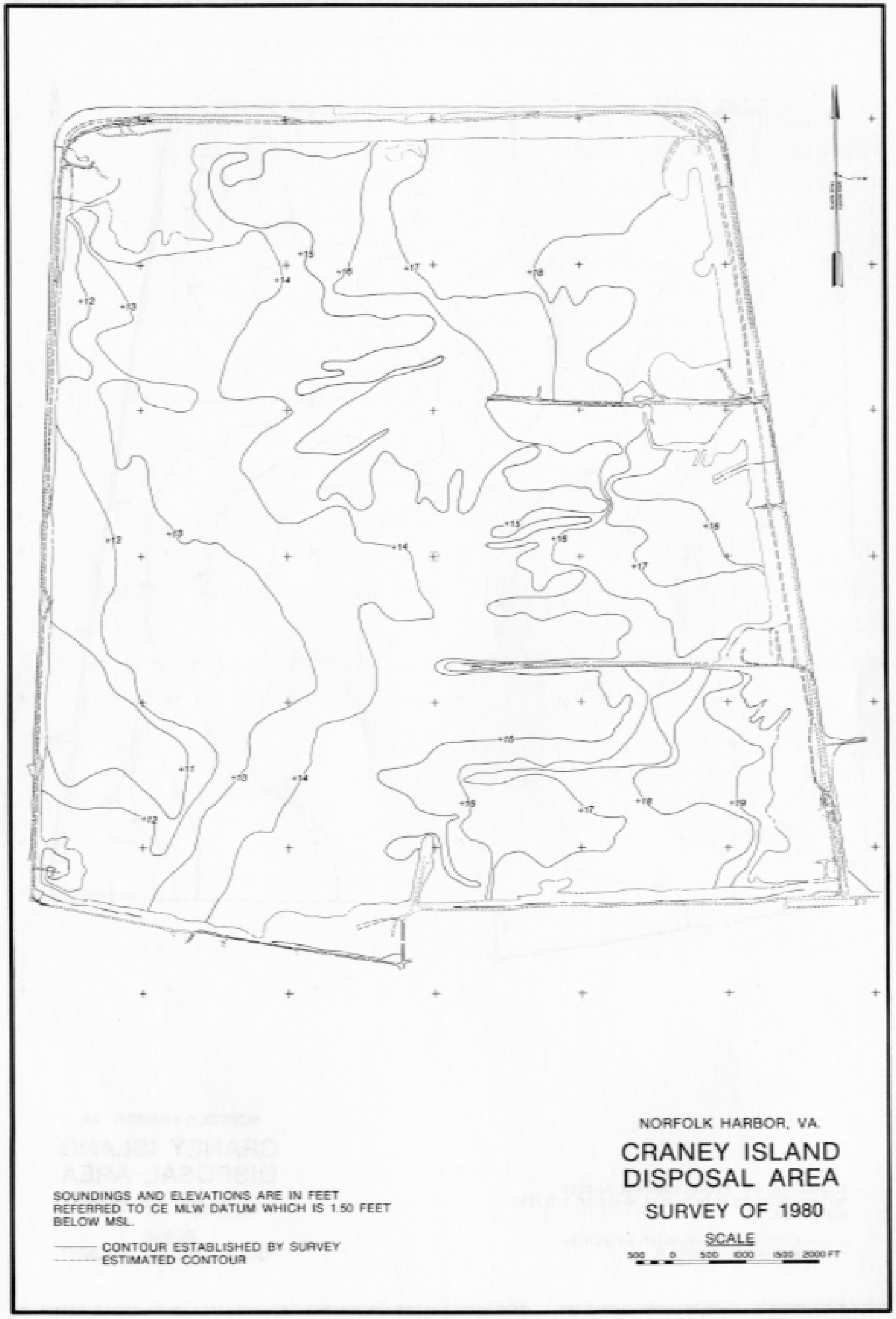
SCALE

500 0 500 1000 1500 2000 FT

SOUNDINGS AND ELEVATIONS ARE IN FEET REFERRED TO CE MLW DATUM WHICH IS 1.50 FEET BELOW MSL.

——— CONTOUR ESTABLISHED BY SURVEY

------ ESTIMATED CONTOUR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+14
+15
+16
+17
+18
+19
NORFOLK HARBOR, VA.
CRANEY ISLAND
DISPOSAL AREA
SURVEY OF 1980
SCALE
500 0 500 1000 1500 2000 FT
SOUNDINGS AND ELEVATIONS ARE IN FEET REFERRED TO CE MLW DATUM WHICH IS 1.50 FEET BELOW MSL.
CONTOUR ESTABLISHED BY SURVEY
ESTIMATED CONTOUR

PLATE B6

APPENDIX C: LABORATORY SEDIMENTATION TEST DATA

1. This appendix presents test results for two series of column sedimentation tests performed on sediment samples taken from locations 1-B and 16-B within the Norfolk harbor channel (see Figure 33). The tests were performed in 8-in.-diam settling columns (see Figure 44) according to the following procedures:

   a. Slurry of sediment and water was prepared at varying concentrations (shown on individual test results) and placed in the settling column.

   b. Depth of solid-liquid interface was recorded with respect to time.

   c. Readings were taken until the maximum point of curvature of depth to interface versus time plot was defined.

2. The slope of the straight-line portion (see Figure 45) defines the zone settling velocity for each respective test (Figure C1-C14). Results of these tests were used to develop relationships of zone settling velocity versus concentration (see Figures 55 and 56). (This appendix is reproduced on microfiche.)

APPENDIX D: LABORATORY CONSOLIDATION TEST DATA

1. This appendix presents detailed test results (Figures D1-D30) for consolidation tests performed on sediment and dredged material samples. Sediment samples were taken from locations 1-B and 31-B (see Figure 33). These samples were run in a remolded condition and loaded using increments of 0.013, 0.02, 0.05, 0.10, 0.25, 0.50, 1.0, and 2.0 tsf.

2. Tests were performed on the following dredged material samples:

Boring	Depth ft	Sample No.
DH-2A-80	9.0	2-5
DH-2A-80	17.0	2-14 (Foundation soil)
DH-3A-80	3.0	3-2
DH-3A-80	15.0	3-8
DH-4A-80	1.0	4-1
DH-4A-80	9.0	4-5

These samples were run in an undisturbed condition and loaded with increments of 0.02, 0.05, 1.0, 0.25, 0.50, and 1.0 tsf.

3. All samples were run on standard fixed-ring consolidation devices using a beam and weight loading system. The time for some loading increments was extended to several days to ensure completion of primary consolidation. (This appendix is reproduced on microfiche.)

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Palermo, Michael R.
Development of a management plan for Craney Island disposal area / by Michael R. Palermo, F. Douglas Shields, and Donald F. Hayes (Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; 1981.
174 p. in various pagings, 6 p. of plates : ill. ; 27 cm. -- (Technical report / U.S. Army Engineer Waterways Experiment Station ; EL-81-11)
Cover title.
"Prepared for U.S. Army Engineer District, Norfolk."
Final report.
Bibliography: 168-170.

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Palermo, Michael R.
Development of a management plan for Craney Island : ... 1981.
(Card 2)

Experiment Station. Environmental Laboratory. V. Title VI. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; EL-81-11.
TA7.W34 no.EL-81-11